CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH
HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

MEMOIR No. 1

GEOLOGY

OF THE

NIPIGON BASIN, ONTARIO

BY

ALFRED W. G. WILSON

OTTAWA
GOVERNMENT PRINTING BUREAU
1910

No. 1091

Frontispiece.

PLATE I.

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L   r part of the Second Falls on the Namewaminikan river

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To R. W. Brock,

Director Geological Survey,

Department of Mines, Ottawa.

Sir,—I beg to submit herewith the following memoir on the Geology of the Nipigon basin, Ontario.

I have the honour to be, sir,

Your obedient servant,

ALFRED W. G. WILSON.

Montreal, April 27, 1909.

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GEOLOGY OF THE NIPIGON BASIN, ONTARIO.

BY

ALFRED W. G. WILSON

INTRODUCTION.

Location and Area.

The area shown on map No. 1090, which accompanies this memoir, comprises about 6,912 square miles of territory. The central position of Lake Nipigon (which occupies about 1,769 square miles when the islands are included), as it appears on the present map, made it advisable to issue on one sheet the two regular map sheets, Nos. 11 and 17, of the Northwestern Ontario series, of which it is composed.

The Nipigon river, the outlet stream from Lake Nipigon, and the largest river flowing into Lake Superior, is crossed by the Canadian Pacific railway 65·5 miles east of Port Arthur on Thunder bay. The main line of the Canadian Pacific railway lies immediately south of the area included within this map sheet, the nearest point being the Nipigon River crossing, four and one-half miles south of the southern edge of the sheet. The projected line of the National Transcontinental railway crosses the northern portion of the area just north of Lake Nipigon, and construction work is now in progress.

In subsequent paragraphs reference is made to the early explorations of parts of this area. Active field work for the preparation of these map sheets began with the work of McInnes and Dowling in 1894. Mr. Dowling continued the work in 1898; in 1901 Parks conducted explorations in the southeast quarter of the area, and in 1902 in the northeast quarter. In 1901 the present writer carried out exploration work in the southwest quarter. In 1902 Mr. McInnes was working on the northwest quarter of the area. In 1908 the present writer, with Mr. Robert Harvie, jr., as assistant, was commissioned to complete the field work for the two map sheets, to

obtain as much additional information as was possible, to correlate all the previous work, and to prepare a report to accompany the present map sheet.

Methods of Field Work.

In the earlier investigations geologic and topographic work had to be carried on simultaneously. During the last field season the writer not only had the advantage of a very nearly completed topographic plan, so that the greater portion of the season could be devoted to the geologic mapping, but also the reports of all the previous work were at his disposal. Unfortunately many of the reports were merely summary reports which did not contain a complete record of the observations made by the writers.

The base map, on which the geologic data relating to this area are shown, has been compiled in the office of the Geological Survey, under the supervision of Mr. C. O. Senécal, Geographer and Chief Draughtsman.

Acknowledgments.

Geologic data.—In addition to the work of the various officers of the Geological Survey staff who have explored portions of the area at different times, the Geological Survey is indebted to the Ontario Bureau of Mines, and to Dr. A. P. Coleman, of Toronto University, for information with respect to the various iron ranges within the area covered by the map sheet.

General.—For assistance rendered in various ways while his parties were in the field, the writer is personally under obligations to the officers of the Hudson's Bay Company at Nipigon and at Nipigon House, and to Mr. P. A. Leitch, of Nipigon, Chief Fire Ranger of the Nipigon Forest Reserve. For advice and assistance rendered when his preliminary report for 190[illegible] was in course of preparation, he is indebted to Professor James F. Kemp, Columbia University, New York, and to Dr. Frank D. Adams, McGill University, Montreal. For laboratory accommodation while this report was in preparation, he is under obligations to Dr. T. L. Walker, Toronto University. The careful painstaking work of Mr. Robert Harvie, jr., during the field season of 1908, has made it possible to present more geological detail on the accompanying map sheet than could otherwise have been done.

HISTORICAL REVIEW OF THE GEOGRAPHIC AND GEOLOGIC EXPLORATION.

Period of Early Exploration.

Geographically, Lake Nipigon was the last of the great lakes of the St. Lawrence system to be discovered by the Europeans of the seventeenth century. History is silent as to who was the first explorer to set foot on the shores of this lake.

Between the years 1658 and 1660 the adventurer and explorer Pierre Esprit Radisson and his brother-in-law, the trader Médard Chouart Groseillers, both from Three Rivers, Quebec, were trading in the country south and west from Lake Superior. During the course of their sojourn in the wilderness they appear to have heard of the 'Bay of the North' from the Indians. In the year 1660 they returned to Quebec, and it was not until the following year that they were able, with considerable difficulty, to return to the north-west. They went back, however, with the intention of finding their way to the great bay in the north of which they had heard, though they do not appear to have divulged any information of their plans. In his journals Radisson naïvely writes: 'My brother and I considered whether we should discover what we have seene or no: and because we had not a full and whole discovery, wch was that we have not been in the bay of the north, not knowing anything but by report of ye wild Christinos, we would make no mention of it for feare that those wild men should tell us a fibbe. We would have made a discovery of it ourselves and have an assurance, before we should discover anything of it.'[1]

The winter of 1661-2 was probably spent amid much hardship in the country north and west of Lake Superior, with a large band of starving Crees. In the spring of 1662 began the eventful journey by which the existence of an overland route to the Bay of the North was established. It is not certainly known by what route the two French traders reached the bay, though it seems probable that it was by way of Lake Winnipeg and the Nelson river. By what route

[1] The Voyages of Peter Esprit Radisson, Prince Society, Boston, p. 172.

they reached Lake Winnipeg is also problematical. Many of the early maps show a supposed connexion between Lakes Nipigon and Winnipeg, and do not indicate the more western route via the Lake of the Woods. There is a good canoe route northward from Lake Nipigon to Lake St. Joseph, and thence by Lac Seul, the English river, and the Winnipeg river to Lake Winnipeg, and there is a possibility that this is the route followed by Radisson and Groseillers. There is also a good route from the northeast of Lake Nipigon, via the Ombabika river and Summit lake to the Albany river, and thence to James bay—a route now frequently used by Crees from the lower Albany.

Whether or not Radisson and Groseillers actually traversed Nipigon waters in the course of their exploration in 1662 is uncertain, though there is reason to believe that if they did not actually see the lake they at least knew of its existence.

So far as the writer has been able to learn from an investigation of all the old maps available in Ottawa, and in the Library of Congress at Washington, Lake Nipigon first appears on the Jesuit Relations map of 1671, being represented but not named. The country adjacent is called the country of the Kilistinons (or Crees). It is interesting to note that it is not shown on the maps of contemporary geographers for some years later. G. Sanson's Map of Amérique Septentrionale, 1669, does not show the country west of the Sault. Joliet's map, 1674, shows Lake Superior, but not Lake Nipigon. The same is true of the Carte de la Louisiane, by Louis Hennepin, in 1683. The lake, still without a name, appears on a chart preserved in the Dépôt Géographique du Ministère des Affaires Etrangères, in Paris, entitled 'Carte de la Louisiane.' This plan also shows the 'Golfe de Hudson' and 'Port Nelson que Patisson nomme Bourbon.' A river called the 'R. Mononopaouy' is shown entering Lake Nipigon from the northwest. The geographer is not named, though the chart is from the collection of J. B. Bourguignon D'Anville, and dates from some time subsequent to 1682.

On a map which was published not later than 1680, the original of which is on file in the library of the Dépôt de la Marine, in Paris, under the file number B. 4044-47, Lake Nipigon is named for the first time as 'Lac Alimibig,' and the people inhabiting the country are called 'Ouanaouantagouk.'

On a map by L. Jolliet, November 8, 1678, the original in the National Library, Paris, Cartes Vol. 388 (153), primarily intended

to show the route between Tadoussac and Hudson bay, 'Lac Alimibegong' appears for Lake Nipigon, the Nipigon river is shown but not named, and a note is appended, 'Passage de tous les sauvages.'

The map entitled 'Novissimae Americae descripto,' by F. de Witt, Amsteldami, 1678, also shows Lake Nipigon as the westerly limit of discovery at this date.

The Carte de la Louisiane by Jean Baptiste Louis Franquelin, 1679-1682, primarily intended to show La Salles' discoveries, shows 'Lac Alemenigon,' with the 'R. Mononepaouy' entering from the northwest.

Robert Morden's 'A new Map of the English Empire in America,' 1695, shows Lake Superior, or Nadouessions, and Lake Nipigon, but does not name the latter. 'Forts Duluth' is shown at the northeast corner of Lake Nipigon.[1]

The third chart on which the lake is named is that by H. Iaillot, Paris, 1696, entitled 'Le Canada.' Here the lake is called 'Alemenipigon.' This map also shows Fort Duluth on Lake Nipigon, as in Morden's map, and is probably either a copy or from the same source.

Pierre Mortier shows Lake Nipigon on his 'Partie Orientale de l'Amérique Angloise,' Amsterdam, 1700. The map is in part probably a copy of Morden's map of 1695. At the northeast corner of Lake Nipigon he notes, 'Poste du St. Duluth pour empecher les Assinipoels et autres Sauvages de descendre ala Baye de Hudson.'

Guillaume de l'Isle's map of 'L'Amérique Septentrionale,' 1700 shows 'L. Alemipigon.'

Lahontan shows 'Nemipigon' on a general map of New France and Canada, 1703. He also shows the Nipigon river as the 'St. Laurens River,' and connects the outlet of Lake Winnipeg (called lake of ye Assinipovals) with Nipigon.

Guillaume de l'Isle, in his 'Carte d'Amérique,' 1722, calls the lake 'Lac Nepigon.' A number of contemporaries and some later geographers retained the older name, 'Alemipigon,' with various modifications in the spelling, for a number of years after this.

J. B. B. d'Anville in his map of 'Amérique Septentrionale,' 1746, shows 'Lac Alemipigon' and the 'Alemipissaki' river, the latter being the river to which Lahontan applied the name St. Laurens in 1703.

[1] This is probably the outpost known as Fort Maune and established about 1684. See Atlas of Canada, Department of the Interior, 1907, Map 32.

Herman Moll, in a map of North America, 1720, uses 'L. Nemipigon' and 'R. St. Laurens.'

A map of 'Amérique Septentrionale par le Docteur Mitchel,' 1756, is interesting in that while it shows 'Lac Nepigon,' it places Fort Duluth east of what is now St. Ignace island at the mouth of a river that corresponds in location to the Jackfish river. The river is called 'R. Bagouagache,' and the note is appended, 'Ancien Fort du Sr. du Luth pour empecher les Kilistinons de descendre dans la Baye d'Hudson par les Rivieres.'

Thos. Gefferys in his 'Carte Nouvelle des Possessions Angloises en Amérique,' 1777, uses the spelling 'Nipigon' for the first time. He indicates the Nipigon river as R. de Alempissaki.

The information given on these earlier charts seems to indicate that prior to 1700 the route via the Nipigon river and lake, thence to Lake St. Joseph, Lac Seul, the English river, Winnipeg river, and Lake Winnipeg was the only one known to geographers contemporary with Radisson and Groseillers, and hence makes it not improbable that their route to the west and north on that memorable fourth voyage in 1661 1663 was by this chain of rivers and lakes. It was not until nearly sixty-five years later that the route via the Pigeon river to the Lake of the Woods became known. That the first explorers may also have learned of the route from the northeast angle of Lake Nipigon, via the Ombabika river and Summit lake to the waters of the Albany river, is a possibility. The erroneous location of 'Forts Duluth' on Morden's map of 1695 hints at a knowledge of the existence in this quarter of a route to the great bay. De l'Isle's map of 1703 appears to be the first plan on which a large river flowing eastward to James bay is actually delineated. This stream is called the Rivière du Parray, and is now known as the Albany. The route leading to Lake Winnipeg is shown more prominently.

For almost two centuries following the first exploration of Radisson and Groseillers little additional knowledge of the country north of Lake Superior appears to have been made public. Numerous fur traders must undoubtedly have traversed its streams and portages, but they have left no written records that are accessible. Following the occupation of certain districts by French traders from Three Rivers and Montreal, the two great rival corporations, the Northwest Company and the Hudson's Bay Company, both had important trading posts on Lake Nipigon nearly two hundred years ago. Such

knowledge as was gained with respect to the country was the property of private interests and was never made public.

It was not until 1860 that any official survey was attempted. In that year the Crown Lands Department of Ontario despatched J. W. Herrick to run a colonization line around part of Lake Superior and to explore the count n either side. This work, which occupied three years, began at a point on Salter's base line (1857) near Sault Ste. Marie, and ran N 18° W, 112 chains; W 48 miles, 26.4 chains; N 18° W, 57 miles, 40.9 chains; N 87° W, 50 miles; N 71° W, 48 miles, 49.56 chains; S 49° W, 82 miles, 30 chains; terminating on the Kaministikwia river near the outlet of Dog lake. This line in part crosses the area within the limits of the present map sheet, and is shown on the plan. It has formed the base from which practically all other surveys have started. Mr. Herrick also surveyed the Nipigon river.

In 1869, Dr. Robert Bell was despatched to make a geological examination of the country lying on the north side of Lake Superior. During the course of this work a little more than two months was spent in the Lake Nipigon basin, the greater portion of the time being given to the mapping of the shores of the lake and the more important islands adjacent. Details of the work, and the general results of this, the first scientific investigation, are given in Bell's report for 1870.

Period of Railway and Land Exploration.

While Bell was in the field in 1869 he received additional instructions from the Minister of Public Works, Hon. Mr. McDougall, to make all possible observations with a view to ascertaining the practicability or otherwise of a railway to the North West Territories through this district, and on his return to the office he made a special report to the Secretary of State with respect to this matter.

Between the years 1871 and 1875 a number of traverses were made by engineers in search of a feasible route for the line of railway that is now the Canadian Pacific railway.

Between 1905 and 1908 a number of traverses were made across the northern portion of the area for the National Transcontinental railway, now under construction.

Most of these traverses were run by transit and chain, profiles also being prepared. The more important lines have been laid down on the accompanying map, and form the basis of the triangulation

network upon which all the available information has been plotted. The scientific information furnished by these explorations has been very slight.

Land Surveys.

Herrick's line of 1860-2 was the first work of the Crown Lands Department in this district. In 1870 this department despatched Wm. Beatty to run an exploration line through the country east of Lake Nipigon, and to explore the country adjacent to this line. His line, which is shown on the present plan where it lies within the district covered by the map sheet, began on the east shore of Lake Nipigon, north of Livingstone point, and ran S 50° 3′ E 70 miles, 12 chains, to Long lake; thence crossing the lake, it ran S 87° 7′ E 46 miles to Pic river. This line was really a preliminary exploration line for the Canadian Pacific railway.

In 1873 the township of Nipigon was laid out by A. B. Scott.

In 1892 the township of Booth was surveyed by B. J. Saunders.

In 1893 the township of Purdom was laid out by B. J. Saunders.

In 1894 the township of Ledger was laid out by T. B. Speight.

In 1900 a base line was run west from the northwest corner of the township of Purdom to the Black Sturgeon river, by David Beatty.

In this same year the Ontario Bureau of Mines despatched ten exploration parties into northern Ontario. Portions of the area within the present map sheet were traversed by some of these parties. Party number 6, in charge of Mr. Joseph M. Tiernan, with A. H. A. Robinson as geologist, were working in the district northeast of the lake. Party number 7, in charge of H. B. Proudfoot, with F. J. Snelgrove as geologist, ascended the Wabinosh river towards the northwest. Party number 8, in charge of David Beatty, with A. H. Smith as geologist, explored the Kaiashk River valley, and northward to Wabinosh lake. During the latter part of the season they were working in the country south and west of Lake Nipigon, including Black Sturgeon lake and river, and some of the tributary streams.

In 1903 a meridian line was run north and south from the west end of the base line run by Wm. Beatty in 1900, and the township of Innes was also laid out on the south shore of McIntyre bay, by A. H. Macdougall.

Period of Scientific Exploration.

The period of scientific exploration really began with Bell's work in 1869. His work, and that of his assistants, was confined to the

shores of the lake and to the valleys of the principal streams, and served to establish the general nature of the geology of that portion of the district immediately adjacent to the lake, and to show the distribution and extent of the more important formations. Subsequent more detailed work, with the aid of more accurate topographic maps and methods, has widely increased our geological knowledge and introduced much new and more detailed information.

In 1894, McInnes and Dowling, from the Geological Survey office, surveyed the shores of Lake Nipigon.

In 1898, Dowling completed the map of the lake by making a triangulation survey of the islands. In addition he made micrometer surveys of the lower courses of some of the larger rivers.

In 1900, the explorations of the various parties sent out by the Ontario Bureau of Mines were carried out in this district.

In 1901, Parks explored the southeast quarter of the area shown in this map sheet, making numerous track surveys and mapping the geological features.

In 1901, the writer carried out similar exploration work on the southwest quarter of the area. In addition a micrometer survey was made from the Canadian Pacific Railway bridge over the Black Sturgeon river to Nonwatin lake, and thence, via the Spruce river, over the height of land to Dog lake.

In 1902, Parks explored the northeast quarter of the area, and McInnes was occupied with similar work on the northwest side.

In 1906, Coleman, acting under instructions from the Deputy Minister of Mines for Ontario, assisted by T. L. Goldie and E. S. Moore, made detailed explorations of the iron ranges east of Poplar lodge. These explorations were continued during the season of 1907.

In 1908, Coleman and Moore carried out similar work on the claims east of Black Sturgeon lake, in the vicinity of Round lake, and east of the district around the headwaters of the Onaman river.

In 1908, the writer, with Mr. Robert Harvie, jr., as assistant, spent the season in completing the geological details for the present map. A micrometer survey was made of the Blackwater river from its source near Park lake, to Lake Nipigon. A similar survey was made of the Sturgeon river from Lake Nipigon to beyond the eastern boundary of the area covered by the map sheet.

The writer has had the opportunity of visiting all the important critical localities that are known within the boundaries of the district. In the preparation of the present report he has had at his

disposal the reports of all the previous explorations, several of which are in manuscript form. To avoid making this report unduly cumbersome it has not always been possible, nor was it deemed advisable, to quote from these reports verbatim. Care has been taken to properly acknowledge any information which is used respecting any localities, whether or not they have been seen by the writer.

The writer is responsible for the method, manner, and selection, of the matter presented in this report. To him has fallen the rather difficult, but important task of deciding what shall be chosen from the large mass of detailed information that is now available, for presentation in this report. He has tried to avoid cumbering the report with unimportant detail, but at the same time to include all details that may be of present or future import, to present all information available which may be essential to the proper understanding of the geology of the area, both from a scientific and a practical standpoint, and to carefully and sharply distinguish observed fact from inferred theory.

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GENERAL SUMMARY AND CONCLUSIONS.

The greater part of the district is underlaid by Laurentian gneisses and granites of a great batholithic invasion or invasions. Lying between the large areas of Laurentian rocks, and apparently representing the bases of downfolded portions of a great series of earlier rocks which were invaded by the granite batholiths, are a series of greenstones and green schists, classified as Keewatin. Infolded with the Keewatin rocks, probably belonging to the upper group of the series, are bands of Iron formation. A few small bands of lower Huronian rocks are also known.

The whole series of ancient rocks has been intensely metamorphosed, and the prevailing structures are now nearly vertical and strike to the north of east.

A long period of erosion and relative quiescence appears to have followed the period of metamorphism of the earlier rocks, for a later sedimentary series rests in a nearly horizontal position upon the truncated edges of the schists and gneisses of the earlier period. These latter rocks are, in ascending order, sandstones, shales, and dolomitic limestones, and are classed as Keweenawan.

After the solidification of the Keweenawan sediments, and probably after a large portion of them had been removed by erosion, the district was invaded by diabase, the remnants of which now cover a very large area.

A small amount of faulting, and profound erosion, have greatly modified the features of the region and have led to the development of the present topographic features.

Economically the Iron formation found within the Keewatin schists has not yet been proved to contain important deposits of ore. Further exploration work is required in certain parts of the known areas, but most of the district is not very promising. There is a possibility of future discoveries of more Iron range rocks in the Keewatin series in the northwest quarter of the sheet.

The Keewatin series also contains bands in which quartz stringers and veins have been found containing small values in gold. These occurrences are similar to numerous other known occurrences which

have never proved of great economic importance, though occasionally rich spots are found locally. Auriferous quartz veins of this type are to be looked for throughout the Keewatin area in the northwest part of the sheet.

The agricultural possibilities of the district are very limited, largely on account of the nature of the soil rather than because of adverse climatic conditions. At the north end of the lake there are extensive sandplains, now covered with spruce, that may be of value, and smaller similar plains occur at other points near the lake shores. It is probable that corps of pulpwood could be successfully raised here, and that they will form the most important product for many years to come.

Certain portions of the area contain good pulpwood, but little merchantable timber. Large areas of pulpwood have been destroyed by forest fires, and large areas have probably always been destitute of forest growth because of their scanty soil cover or undrained condition.

The fisheries of Lake Nipigon promise to be very valuable, but their exploitation at the present time would result in the more rapid extermination of the Indian inhabitants of the district by cutting off their chief food supply. Even as it now is they have a hard struggle for existence.

The fur trade of the district has been gradually decreasing, markedly so since the beginning of the present period of active railway exploration and construction.

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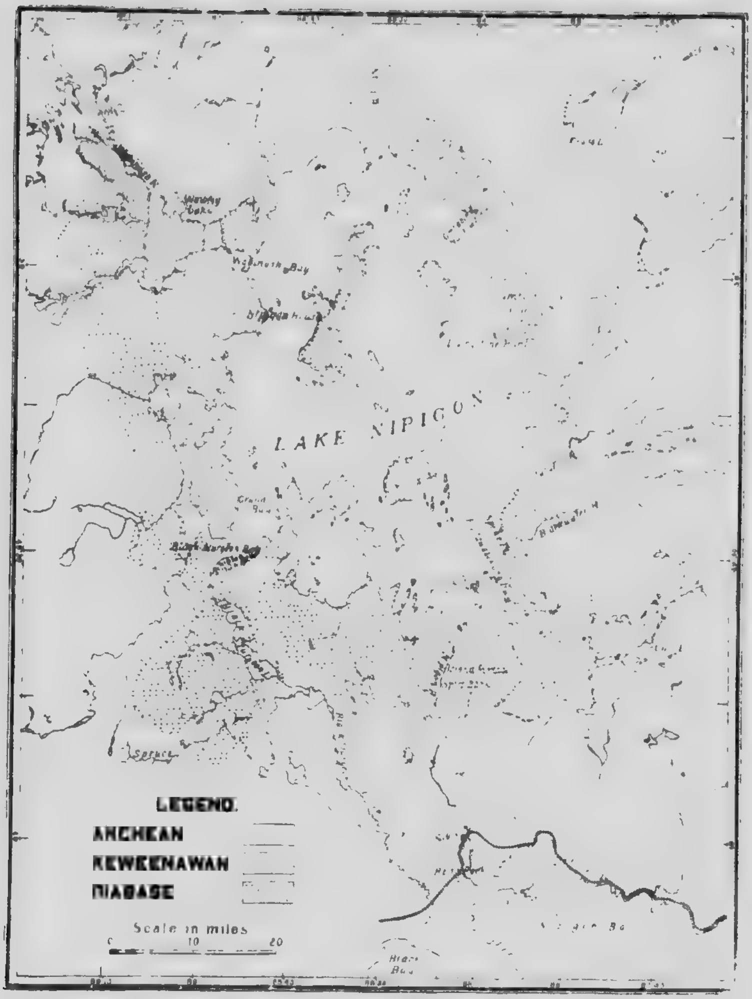

FIG. 1. Sketch plan of Lake Nipigon basin, showing the areal distribution of the principal bed rock formations.
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GEOGRAPHY OF THE NIPIGON BASIN.

Location and Boundaries.

The area included within the boundaries of the Nipigon map sheet is rectangular in outline, measuring about 70 miles east and west, and about 96 miles north and south. It lies approximately between longitude 87° 35′ W and 89° 10′ W, and between latitude 49° 5′ N and 50° 30′ N, though the boundaries of the map are not true north and south or east and west lines. The area embraced by the map sheet is about 6,720 square miles. Lake Nipigon, 1,769 square miles in area when the islands are included, occupies a nearly central position, and the south-flowing Nipigon river traverses the middle portion of the southern half of the area mapped. The southern boundary lies a few miles north of the Canadian Pacific Railway line and Lake Superior; while the northern boundary is close to the Hudson Bay divide. The projected line of the Canadian Northern railway crosses the south and southwest part of the area, and the National Transcontinental railway traverses the district from east to west, just north of Lake Nipigon.

Surveyed Areas.

With the exception of three townships and part of a fourth (Ledger, Purdom, Innes, and part of Booth), the whole area embraced by this map sheet is unsurveyed Crown land—which, however, has been traversed by numerous exploratory surveys. In 1905 the Ontario government set asid an area of about 7,297 square miles around Lake Nipigon as a forest reserve. The boundaries of the reserve nearly coincide with those of the present map sheet.

Drainage and Topography.

Lake Nipigon occupies a nearly central lowland depression, into which are collected the drainage waters from about 80 per cent of the area. In the extreme northeast and northwest corners, north of the Hudson Bay divide, are a few small lakes and streams, the head-

waters of tributaries of the Albany river. In the southeast cor
a few small lakes drain directly into Lake Superior by small sw
flowing streams. About half the drainage from the southw
quarter of the area is tributary to the Black Sturgeon river, a
passes thence directly into Black bay on Lake Superior.

Lake Nipigon, in the central depression, receives the drainag
of the greater number of rivers within the area. The radial po
tion of these tributary streams is one of the most interesting an
striking characteristics of the region. The more important tributa
streams are the Blackwater, Sturgeon (Namewaminikan), and On
(or Red Paint) from the east, all three of which head east of th
area. On the north are the Ombabika, Little Jackfish, Pikitigush
(or Mud), and Whitesand. Of these the Pikitigushi is the only on
heading beyond the north boundary. The Ombabika heads in
shallow marshy lake (Summit lake), whose waters flow in two direc
tions. From the west the three important streams are the Wabinosh
Kabashk, and Poshkokagan rivers, all three of which head west of the
area mapped.

Black Sturgeon lake and the river of the same name drain the southwest quarter of the area. The most important tributary stream from the southwest is the Spruce river. There are no large streams entering Lake Nipigon from the south, and none entering the Black Sturgeon drainage system from the east.

In the southeast quarter of the sheet we find the headwaters of the Pays Plat, Gravel, and Jackpine rivers, all swift-flowing streams with numerous rapids in their upper courses, and all flowing directly to Lake Superior.

The Nipigon river, the largest stream entering Lake Superior, carries all the water of the streams tributary to Lake Nipigon south from Lake Nipigon to Lake Superior.

East, northeast, and north of Lake Nipigon the country forms a portion of the Laurentian peneplain of Canada, and it is characterized by its moderate relief and very even sky-lines. There are a few mesas formed by residuals of the trap sheets at several points in the area, and occasionally a ridge of Archæan rocks rises a little above the general level of the district.

Southwest of the lake the country is underlain largely by old trap sheets, many of which rest upon sedimentary deposits, these in turn resting upon an old crystalline floor of Archæan rocks. The

topographic features are more diverse than elsewhere and the relief is much greater, approaching a maximum of nearly 800 feet.

The radial distribution of the principal streams tributary to Lake Nipigon from the east seems to indicate that the peneplain surface is inclined towards the southwest. In the northeast corner of the sheet the elevation of the watershed is approximately 450 feet above Lake Nipigon. Many of the streams tributary to Lake Nipigon from the southwest flow northeast in valleys which are nearly parallel, and which traverse successively older beds of the Keweenawan formation as they descend towards the lake.[1]

Elevations.

The elevations of the more important topographic features of the district are given in the following table. Other elevations, obtained chiefly from the profiles of railway exploration lines, are given on the map:

	Elevation above sea-level, in feet
Lake Nipigon	852
Kaiashk lake	1,410
Summit lake	1,100
Round lake	1,000 (?)
Caribou lake	1,200
Black Sturgeon lake	832
Little Sturgeon lake	952
Nonwatin lake	729
Frazer lake	1,046
Lake Helen	607
Lake Superior	602

The elevations of the summits of the following prominent topographic features were determined by barometric readings as follows:—

	Elevation above sea-level, in feet
Bluff, foot of Pijitawabik bay, west side	1,430
Livingstone point (east end)	1,330
Haycock mountain, on north shore, Lake Nipigon	1,200 (?)

[1] A more complete discussion of the physiography is given in the section of that name near the end of this report.

	Elevation above sea-level, in feet
Mount St. John, on the north shore, Lake Nipigon	1,330
Inner Barn island, Wabinosh bay	1,172
Outer Barn island	1,427
Mount Royal, on Jackfish island	1,250 (?)
Tchiatang bluff, cliff 1,200, summit	1,510
Peak on lot 11, con. VII, Booth	1,640

Climate.

No systematic series of observations extending over a long term of years is available for study. In general, it may be said that the climatic conditions are similar to those of the whole district north of Lake Superior. In summer the daylight period is long, between sixteen and seventeen hours, as may be inferred from the mean latitude of the locality. During the months of July and August there are often warm days in which, except close to the large lake, the air becomes extremely warm. On nearly bare surfaces, such as are found at the summits of the trap masses, the temperature must occasionally be not far from 150° F. at the hottest time of the day. The nights are usually cool, but not unpleasantly so. During the winter the daylight hours are correspondingly shorter, the weather cold, and all the lakes and rivers, except in the rapids, freeze over. The total amount of rainfall per annum has not been ascertained, though it must be considerable, and is probably between 20" and 25". The snow in the winter lies from 3 to 4 feet in depth, though occasionally it is less than this.

In regard to the climate of the district as a whole it may be said that the advent of spring is from four to five weeks behind that of the region along the north shore of Lake Ontario, with a correspondingly earlier setting in of winter. The winter is long continued and more severe than in the older settled parts of the Province, and the summers are correspondingly shorter and cooler. The lakes and streams are generally free from ice towards the middle of May, and close again early in November. The average precipitation during the year is probably greater than in the southeastern portions of the Province.

Common Plants and Animals.

ECOLOGICAL NOTES.—The distribution of the vegetation with respect to the geologic and topographic features is a subject of [illegible] interest. With the exception of a few relatively small absolutely bare spaces on the rock uplands, and some less barren yet bare spaces on sandplains, the greater part of the area is carpeted [illegible]. The [illegible] are found everywhere; the principal [illegible] most prevalent, and which shall occur in any district to the exclusion of the other seems dependent on the position of the water-table with respect to the surface, the position of the local water-table being a function of the physical geography. The character of the surface varies considerably; in some regions there is almost no soil, in the usual sense of the term, to be seen, the surface consisting of loose boulders, these varying in size, but averaging perhaps a foot and a half in diameter. At the other extreme we have the glacial and alluvial sandplains with fine textured soils.

In the southern part of the region much of the surface, where not bed-rock, consists of a boulder pavement with a small amount of interstitial soil. The boulder pavements are absent from most of the eastern portion of the area, and such soils as there are consist of finer debris, chiefly of glacial origin.

Where the water-table is within a short distance of the average surface, say 2 or 3 feet, as a maximum, the cover is almost universally *Sphagnum* moss. On the uplands south of the Poshkokagan river one can travel for miles over a cover of this kind, where the moss is about 2 feet thick, but occasional holes are seen leading to water-filled interstices among the boulders. In places where the moss cover reaches this thickness there is usually a tangled mat of roots mingled with it and overlying the boulders. More often the cover is thinner than here noted, but the *Sphagnum* moss occurs widely in the various muskegs of the region. Where the water-table lies at a somewhat greater distance below the level of the average surface the moss cover is generally *Hypnum triquetrum*, and usually the cover formed by this moss and its associates is thinner than that formed by the *Sphagnum*. Flat and undrained surfaces of bed-rock are nearly always covered by *Sphagnum*, while slightly inclined surfaces (when more or less shaded by forest trees growing in the scanty soil found in adjacent [illegible] and hollows so that the surface is less apt to become quickly dry) are usually covered with the *Hypnum* or some of its associates.

On the larger higher and drier surfaces the cover is usually a reindeer moss (commonly *Cladonia rangiferina*), or some closely related lichens. There are a few small areas, each rarely over an acre in extent, underlain either by bed-rock or by the boulder pavement, which are destitute of any noticeable vegetable covering, except for a few thin lichens. Bare areas underlain by sedimentary rocks are very rare.

The distribution of the forest trees on the sandplains is remarkably uniform. On the upper higher drier parts of the plain, near the crest line, the trees are usually jackpine, with relatively open woods offering easy passage. These merge gradually with a zone of black spruce, a few deciduous trees occurring near the zone of transition. The black spruce cover the greater part of the plain, are closer together, and, usually, underfoot we find a matted cover of mosses. Frequently there is also a tangled thicket of low shrubs particularly Labrador tea, *Ledum groenlandicum*, and much fallen timber. Where the plain merges with the general surface of the country the black spruces become smaller, and in the lower areas frequently give place to tamarack and the typical sphagnum-covered muskeg.

On the less steep portions of talus slopes, on the well-drained but not dry parts of sandplains, and on the gently inclined plains underlain by boulders and a considerable quantity of interstitial soil, the forest is usually of deciduous trees, chiefly birch and poplar.

The more luxuriant forest growth is confined to the river valleys and to certain portions of the uplands. On the higher parts of the uplands the trees become very much stunted: in places, owing to the lack of good drainage and to the presence of cold ground water, and in other areas because of the lack of sufficient soil and moisture.

Flora.—The flora of the district is that characteristic of the northern part of the temperate zone everywhere on the Laurentian peneplain of central Canada. The following are the principal trees noted:—

Acer spicatum, mountain maple.
Acer pennsylvanicum, striped maple.
Acer rubrum, red maple.
Crataegus tomentosa (?), hawthorn.
Cornus stolonifera, red dogwood.
Dirca palustris, moosewood.
Fraxinus sambucifolia, black ash.

Ulmus americana, white elm.
Betula papyrifera, canoe birch.
Betula lutea, yellow birch.
Alnus in[illegible]
Corylus americana, hazelnut.
Populus tremuloides, aspen poplar.
[illegible] *grandidentata*, large toothed aspen.
Populus balsamifera, balsam poplar.
Pinus strobus, white pine ([illegible])
Pinus resinosa, red pine.
Pinus banksiana, jackpine.
Picea nigra, black spruce.
Picea alba, white spruce.
Abies balsamea, balsam fir.
Larix [illegible], tamarack.
Thuja occidentalis, white cedar.
Taxus canadensis, ground hemlock.

VERTEBRATE FAUNA. While the following list is not exhaustive, it probably includes all the more important vertebrate animals which are native to the district. No systematic collections were made, but from time to time records of the occurrence of such species as happened to be observed during the course of the other work, were made. The lists of fish and birds are necessarily very incomplete:

Fish.—

Acipenser rubicundus, lake sturgeon
Ameiurus nebulosus, catfish.
Coregonus artedi (?), lake herring.
Salmo fontinalis, var. *Nipigonensis*, silver trout.
Salmo fontinalis, brook trout.
Salvelinus namaycush, great lake trout.
Esox lucius, pike or jackfish.
Micropterus dolomieu, small mouthed black bass.
Micropterous salmonoides, large mouthed black bass.
Stizostedion vitreum, wall-eye pike
Moxostoma (sp.), sucker.

Reptiles: Specimens of the Mud puppy, *Necturus maculatus*, and at least two species of Salamander, one of which was a Spotted Salamander, were seen. Several species of toads and frogs occur,

but the common frog of more southern parts of Ontario is rare. Garter snakes are occasionally seen, and seem to be the only kind of snake found in the district.

According to the Indians, a species of tortoise, probably *Chremys* sp., occur on a small lake, the first west of Black Sturgeon lake on the Circle Lake system.

Birds.—In addition to numerous species of sparrows, warblers, hawks, and other small birds, not known to the writer at sight, the following species were noted:—

Podilymbus podiceps, pied-billed grebe.
Urinator imber, loon.
Larus argentatus, herring gull.
Sterna hirundo, common tern.
Merganser americanus, American merganser or shelldrake.
Merganser serrator, red-breasted sawbill.
Anas obscura, black duck.
Anas carolinensis, green-winged teal.
Anas strepera, grey duck.
Charitonetta albeola, butter ball.
Branta canadensis, Canada goose (spring and autumn only).
Botaurus lentiginosus, bittern.
Ardea herodias, great blue heron.
Philohela minor, American woodcock.
Actitis macularia, spotted sandpiper.
Dendragrapus canadensis, spruce partridge.
Borasa umbellus, ruffed grouse.
Haliaetus leucocephalus (Linn.), bald eagle.
Pandion haliætus carolinensis (Gmel.), American osprey or fish hawk.
Megascops asio (?), screech owl.
Bubo virginianus, great horned owl.
Ceryle alcyon, belted kingfisher.
Dryobates villosus, hairy woodpecker.
Dryobates pubescens, downy woodpecker.
Colaptes auratus, yellow hammer, or flicker.
Chordeiles virginianus, night hawk.
Cyanocitta cristata, blue jay.
Perisoreus canadensis, Canada jay.
Corvus corax, raven.

Corvus americanus, crow.
Pinicola enucleator, pine grosbeak (autumn).
Sitta carolinensis (?), white-bellied nuthatch.
Parus atricapillus, titmouse, or black-capped chickadee.
Merula migratoria, robin.

Mammals:

Lepus americanus, hare.
Erethizon dorsatus, Canadian porcupine.
Fiber zibethicus, muskrat.
Castor canadensis, beaver.
Tamias striatus, chipmunk.
Sciurus hudsonicus, red squirrel.
Cariacus virginianus, Virginia deer (rare).
Alce americanus, moose.
Rangifera tarandus, woodland caribou.
Ursus americanus, black bear.
Lutra canadensis, otter.
Mephitis mephitica, skunk.
Mustela americana, marten.
Mustela pennanti, fisher.
Putorius vison, mink.
Putorius erminea, weasel.
[illegible]*pes vulgaris*, var. *fulvus*, red fox.
[illegible]*nis lupus*, wolf.
Lynx (*Felis*) *canadensis*, Canada lynx.

Cultivation and Occupation.

At the present time there are no permanent settlements of importance within the area. The total Indian population of the district is 528 persons, distributed among 133 families. These people are distributed in a number of reserves located as follows: at the mouth of Nipigon river, at the foot of McIntyre bay, at the mouth of Kaiashk river, and at Jackfish island. There are also a few families living at several other points on the lake.

On most of these reservations the inhabitants have small gardens, in which they cultivate potatoes and occasionally a few other vegetables. Their chief source of food supply is the fish from Lake Nipigon, particularly sturgeon and grey trout.

The construction of the National Transcontinental railway will probably lead to the location of two villages in the northern part of the area—one at the head of Ombabika bay, where the trading post of the Révillon Frères is now situated, and the other at the crossing of the Pikitigushi river. At this latter point there are extensive lacustrine sandplains which offer a soil that may prove suitable for cultivation when cleared. A small settlement has already been started.

At Nipigon House the Hudson's Bay Company has an old established post, with a permanent resident agent in charge.

There is also an Anglican mission at the reserve on the south shore of McIntyre bay, with a resident minister in charge.

Small temporary settlements have been started at South bay and at Camp Alexander, the two ends of a temporary tramway built for the purpose of transporting men and supplies northward to Lake Nipigon in connexion with the construction work on the National Transcontinental railway.

Resources.

Forest Areas.—*Pulpwood.*—The spruce growing near the shores of the lakes and in the valleys of all the principal streams is of a size suitable for the manufacture of wood pulp. The greater portion of the trees growing on the dry or on the undrained uplands is too small to be of economic value. No sufficiently accurate returns are available to warrant a statement as to the total area of merchantable pulpwood within the boundaries covered by the Nipigon map sheet.[1]

Jackpine suitable for pulpwood also occurs in a number of localities in very considerable quantity.

Other timber trees.—There are no large areas of importance in which timber trees, other than those suitable for pulpwood, occur. There are a few small areas of white spruce and red pine that may be useful locally for square timber. The red pine are confined almost wholly to the country near Black Sturgeon lake.

White cedar is found in a few localities, in river bottom lands and in some swamps, of a size that may be useful for ties and posts.

[1]For reports and approximate estimates see Report of the Surveys and Explorations in Northern Ontario, 1900, Bureau of Mines, Toronto, 1901.

BURNED AREAS.—The precise limits of the burned areas have not been determined. The following information has been compiled from the reports by Parks and from the writer's field notes:

(1) Valley of the Poshkokagan river, about twelve square miles.

(2) Southwest corner of the map sheet. The extensive fire which destroyed the timber around Dog lake reached the southwest portion of this area.

(3) Portions of the northern part of the township of Booth. The pulpwood in this area was cut some years ago.

(4) Portions of the township of Purdom and the country west of this.

(5) The eastern portion of the township of Ledger and the country to the east of this. The pulpwood north and east of Lake Polly in the township of Ledger has been cut.

(6) Burned areas of unknown extent occur south of Lake Jean for at least twelve miles, in the vicinity of the neighbouring lakes, and also around the headwaters of the Blackwater river. There is no reason to suppose that the two areas here mentioned are connected, since there are considerable areas of good spruce south of the Blackwater river and west of Blackwater lake.

(7) A large district east of Ombabika bay and along the line of the National Transcontinental railway, area unknown; Parks' estimate possibly about sixty square miles.

(8) An area varying in width from three to five miles, stretching northeast from about three miles south of North Wing lake to beyond Crooked Green lake, estimated by Parks at about 160 square miles.

(9) An irregular area around Cross and Marshall lakes, probably about 100 square miles.

(10) A large area north of Round lake and extending for some miles east of the Pikitigushi river. The country between Round lake and Caribou lake at the northwest corner of the map sheet has been burned over several times. This is the largest continuous area within the limits of the district in which the forest has been destroyed.

FISHERIES.—Lake Nipigon will probably be a source of supply of large quantities of food fishes for the markets of Ontario. Grey trout and whitefish are particularly abundant. It must be pointed out that the fish of the lake form one of the staple articles of food

of the Indians now occupying the territory. Any operations which will tend to reduce the fish supply of the lake will be a matter of very serious moment to them. Even under existing conditions they occasionally are threatened with very serious famines.

FURS.—In past years the country in the vicinity of Lake Nipigon has been the source of a large supply of furs of the various kinds of mammals common to the cold temperate climatic districts of central Canada. In recent years there has been a marked decrease in this supply, one of the animals, the beaver, having almost disappeared. The construction of the National Transcontinental railway will tend to diminish still further the output of this region.

MINING.—At the present time no mines are in operation in th district. Some small areas that may be of economic importance ar known. Their extent and character will be discussed in the section entitled Economic Geology.

AGRICULTURE.—There are no agricultural products grown in th region beyond those required for the immediate necessities of the inhabitants. There are extensive sandplains and alluvial flats that seem to have a rich soil, that in future years may serve a larger population. On the whole, the agricultural possibilities of the region are very limited.

WATER-POWERS.—There are a number of places on several of the principal rivers tributary to Lake Nipigon where excellent small water-powers could be developed for local use were they ever required, either for the manufacture of wood pulp and its products, or for mining work.

The water-powers of the Nipigon river will be of more than local importance, when utilized, as they are probably one of the largest and best of the more readily accessible undeveloped water-powers in Canada.

STRATIGRAPHIC GEOLOGY.

Introduction.

The general distribution of the rocks of the various formations represented within the boundaries of this district is best seen by referring to the accompanying map. The greater portion of the area is underlain by Laurentian granites and gneisses. Intimately associated with the Laurentian rocks in many localities are small belts of metamorphic rocks, often grey schists, which under Lawson's classification would have been called Couchiching. Here it has not been possible to map them separately, and they have not been differentiated from the Laurentian.

There are some other areas of metamorphic rocks, readily distinguished from the Laurentian, and usually having been invaded by the latter along the lines of contact between the two. These rocks are basic greenstones and green schists, and are classified as Keewatin.

These two series of rocks probably underlie the whole district. In certain localities of limited area we find resting unconformably upon the truncated edges of the upturned metamorphic series a group of indurated sediments, ranging from conglomerates and sandstones to dolomites. These rocks belong to the old Nipigon series of Bell, and are classed as Keweenawan.

Still later than these are sheets of diabase, which form the upper rock of large areas.

Pleistocene and old lake deposits form very considerable portions of the present surface soils, and are somewhat irregular in their distribution over the area, so much so that no attempt has been made to show their distribution on the map.

Table of Formations.

ARCHEAN..........	*Keewatin*..	Greenstones, green schists, mica schists, amphibolites, iron formation with some slaty schists and arkoses.
	IGNEOUS CONTACT.	
	Laurentian.	Granites, gneisses, grey schists.

GREAT UNCONFORMITY.

	Huronian (lower)	Conglomerate, and probably som arkoses, and slates.
	VERY GREAT UNCONFORMITY.	
PALÆOZOIC (?)..	*Keweenawan* .. .. (or *Nipigon*)..	Conglomerates, sandstones, shales and dolomites.
	GREAT UNCONFORMITY.	
POST-PALÆOZOIC (?)..	*Igneous invasion*..........	Diabase sheets and [illegible] Later [illegible]
	GREAT UNCONFORMITY.	
CENOZOIC..	*Pleistocene*	Till, morainic materials, gravels, sands.
	Post-Pleistocene .	Lake deposits, peat, marl.

Summary Description of Formations.

Mc e than ninety-five per cent of the rocks mapped as Keewatin consist of various types of schists and eruptives, formed chiefly from basic materials. Practically all of them contain enough chlorite or hornblende to give the rock a greenish colour. Associated with the Keewatin bands of the Sturgeon River area are some schistose arkoses containing a good deal of quartz, some pale green schists containing carbonates and quartz, and some rather acid plutonic rocks like diorite or granodiorite. The highest or nearly highest rocks of the Keewatin, which constitute the Iron formation, are nearly all composed of silica, in some form, associated with an oxide of iron.

The Laurentian is represented by some very large granite batholiths. Associated with these granites are gneissoid granites and gneisses. There are also strips, bands, and patches of crystalline schists intimately associated with the principal granite masses, which are probably the metamorphosed remnants of a series of rocks older than the Keewatin. Separate mapping of this series was not attempted because of the large amount of complex detailed work that would be required.

The lower Huronian is represented almost wholly by a few well-defined bands of conglomerate. This conglomerate contains pebbles and other fragments derived from all the earlier rocks of the district in which it is found, including jasper fragments from the iron ranges. It is thus of much importance geologically, as it affords a well defined horizon for the subdivision of the Archæan.

The Keweenawan formation occurs over wide areas to the south and southwest of Lake Nipigon. Detached remnants of the same formation occur as outliers at many points along the shores of the lake. The basal beds are usually conglomerates containing fragments derived from the underlying Archaean. These are followed by sandstones, shales, and dolomites in ascending order. The highest beds of the series are found chiefly in the southwest portion of the area mapped.

The youngest rock in the region is a diabase. This rock occurs as intrusive dikes and sheets. Vast sheets of the diabase now also overlie, unconformably, representatives of all the earlier formations. The writer considers these capping sheets, as they have been called, as probably the remnants of once extensive surface flows. The data on which this conclusion is based are set forth at some length in succeeding pages of this report.

Records left by the ice of the glacial period are found everywhere in the area. Except on the fronts of some of the diabase cliffs, almost all of the rock exposures show glaciated surfaces. Much of the loose waste that covers the country is of glacial origin, though much of it has not been transported far. There are, however, several large areas where the loose waste now forming the soil was deposited near the margin of a great glacial lake, or probably a successive series of lakes of changing elevation and outline.

Description of Formations.

Keewatin.

There are four areas in which rocks of this formation occur:—

Black Sturgeon Lake area—where about six square miles are known to be underlain by rocks of this formation.

Sturgeon River area—on the east shore of Lake Nipigon, including most of the district in the basins of the Blackwater, Sturgeon, and Onaman (Red Paint) rivers: in all about 656 square miles.

Cross Lake area—a portion of the district lying between Cross and Marshall lakes in the northeast corner of the map sheet.

Round Lake and Caribou Lake area—lying north of Round lake and extending west beyond Caribou lake. Only the southern part of this area lies within the boundaries of the northwest portion of the district mapped.

BLACK STURGEON LAKE AREA.

East of the south end of Black Sturgeon lake [illegible] small area of [illegible] schists forms a prominent [illegible] the lake shore. The width [illegible] about two and one-half miles. The schists [illegible] to the northeast, at distances varying from [illegible] from the lake. The foreground between [illegible] Black Sturgeon [illegible] underlain by Keweenawan sediments.

The schists are very fine textured, dark [illegible] and consist largely of hornblende, [illegible] small amount of biotite and feldspar. [illegible] decomposed. The structures are nearly vertical [illegible] N 45° E and N 50° E.

[illegible] RIVER AREA.

Outcrops of schists belonging to this series [illegible] on the shore of Lake Nipigon about one mile north [illegible] mouth of the Blackwater river. With frequent interruptions [illegible] later diabase outcrops at the water's edge, similar rocks are found along the shore as far as the mouth of the creek flowing from [illegible] Wing lake, about 5 miles south of Livingstone point. From this locality northward to the mouth of the Onaman river the basal rocks are Laurentian, but occasional outcrops of the Keewatin are again encountered, north of the Onaman river, in a belt about two miles wide.

Inland the southern boundary of the belt of schists and greenstones probably lies some two miles south of the Blackwater river, though it has not been possible to locate it exactly. North of the Onaman river the boundary is somewhat irregular; but, as far as known, it for the most part lies near the river. Eastward the belt of rocks extends beyond the edge of the area mapped.

Between the east shore of Lake Nipigon and the eastern edge of the area mapped there are probably about 650 square miles underlain by these rocks. The general strike of the structures and of the bands of different kinds of rocks which comprise the series is a little to the north of east, and the entire series has a width of nearly twenty-four miles.

Nearly all the rocks are schistose in structure, though massive varieties occur. Usually the schists are fine textured and the struc-

[illegible] relation between the [illegible] [illegible] ... wide differences [illegible] ... [illegible] ... [illegible] character [illegible] ... [illegible] general [illegible] ... [illegible] of rocks found in the [illegible].

Greenstones. [illegible] ... [illegible] under the general [illegible] ... [illegible] included are highly altered [illegible] ... [illegible] ... have been [illegible] ... [illegible] into chlorite and [illegible] ... [illegible] material [illegible] ... [illegible] rocks which [illegible] volcanics, [illegible] flows, and occasionally show pillow structure [illegible] scattered [illegible] filled with chalcedony, quartz, calcite, [illegible]. In a few places [illegible] varying in size up to pieces nearly 3 feet across [illegible].

Locally it has been possible to recognize several well known types, of which diorite and diabase are the most frequent.

Diorite is found in many places, and is frequently referred to by Parks. Usually it consists [illegible] of hornblende and plagioclase in a more or less [illegible] condition. Several varieties of quartz diorite have been described by Coleman and [illegible] among the rocks associated with the [illegible] of the Sturgeon River valley.

Diabase, now very much altered and decomposed, occurs at least at one locality near the [illegible] of the Blackwater river on Blackwater lake. The augite can still be easily recognized, though the crystals are usually twisted and broken. The feldspar has all broken down, and individuals can only be distinguished with difficulty. Occasionally massive greenstones are found containing large porphyritic crystals of plagioclase associated with more or less altered ferromagnesian silicates. In one locality we noted a greenstone carrying locally large partly decomposed porphyritic augite crystals. The groundmass was largely chloritic material.

Some of the greenstones are undoubtedly altered amygdaloids. In many cases the structure is obscure, in others the amygdaloidal cavities are distinct. Usually the cavities are filled with chalcedony.

quartz, calcite, or oth[illegible] [illegible] chlorite or [illegible]

[illegible]

[illegible] the [illegible] rocks [illegible] the brec[illegible] that [illegible] the shores of Lake Nelson north of the mouth [illegible] Sturgeon river [illegible] fragments varying [illegible] feet across. Al[illegible] [illegible] fragments are angular, and are coloured in various [illegible] green. Many of the fragments [illegible] structure, but [illegible] structures lie at various angles to each other and to the structure [illegible] the adjacent schists. At least five distinct kinds of fragments hav[illegible] been recognized. Some of the lighter coloured ones appear to hav[illegible] [illegible] from a felsite; most of them are varieties of gre[illegible] schists. No fragments of gneiss or granite were found. The cemen[illegible] between the blocks consists of chloritic material probably deriv[illegible] from the same source as the blocks themselves. In many places th[illegible] fragments appear to be closely crowded together and to have littl[illegible] cementing material between them. On wave-swept glaciated surface[illegible] [illegible]

In [illegible] structures [illegible] [illegible] that they are derived from early surface flows of a basal[illegible] [illegible] type.

Green Schists.—The schists are the most wide-spread rocks, and the commonest type is green in tone because of the presence of horn-blende or secondary chlorite. Frequently there seems to be a gradual transition from areas of green schists to areas of greenstone wit[illegible] little or no schist [illegible] the general pro[illegible] cesses of metamorphism these masses of plutonic rocks have been altered at their margins.

Chief among the green schists may be recognized the amphi[illegible] [illegible]tes. They are found in many places, and usually consist alm[illegible] entirely of hornblende associated with a small amount of quartz. Occasionally there is some biotite mica present in small amount. Magnetite in minute particles is almost always present, and pyrite has been noted. Specimens showing all stages of decomposition from the crystalline, little altered, glittering hornblende schist to the h[illegible]ly altered, dull, earthy, greenish tinted chloritic schist may be fo[illegible]d.

There is no sharp line of demarcation between the greenstones and the green schists, but the latter have a parallelism of the re[illegible] crystallized minerals which is lacking in the former. Many of the

green schist, often some of the fragments [illegible] from [illegible] and may have been [illegible] water-formed [illegible] in the formation. In most of them [illegible] quartz [illegible], often with a radiating [illegible] generally [illegible] with [illegible] carbonates, etc. [illegible] fragments [illegible] and [illegible] a little, [illegible] quartz diorite or quartz porphyry."[1]

Carbonate Schists. Occurring with the green schists or associated with the iron formation [illegible] grey or [illegible] schists [illegible] weather rusty, and [illegible] appear to contain a good deal of carbonate. In most cases the carbonate appears to be ankerite containing magnesia or lime, as well as iron. "These rocks vary in composition, some consisting mainly of very fine-textured quartz and feldspar with sericite, having twenty per cent. [illegible] of the ankerite crystals disseminated through the mass. These [illegible] the appearance of [illegible] schists [illegible] crystals [illegible]. Others contain fragments [illegible] and plagioclase along with numerous patches of [illegible] porphyrite or [illegible]."[2]

Slates. There are series of [illegible] sometimes associated with [illegible] schists, but they are [illegible] interbanded with [illegible] formation. The slaty rocks are fine in texture and grey-black to black in colour. "The slates [illegible] entirely recrystallized [illegible] black slate [illegible] its [illegible] from magnetite [illegible] having [illegible] character [illegible] minerals [illegible] quartz [illegible] and chlorite [illegible] and a very few [illegible] tourmaline [illegible] ratile but [illegible] crystals of [illegible]."[3]

Iron Ranges. [illegible] which have been carried on at various times since 1900 have shown that there are three distinct iron ranges in the Keewatin [illegible] east of Lake Nipissing. These ranges [illegible] investigated in considerable detail by [illegible] number of observers. The most detailed work is that by Coleman

Coleman, [illegible] p. 141
Coleman, [illegible] p. 131
[3] Coleman, [illegible] p. 131

and Moore for the Ontario Bureau of Mines during the seasons of 1906 and 1907.[1]

The following description is taken from Coleman's report: –

'At or near the top of the Keewatin occurs the most interestin rock of the region east of Lake Nipigon, the Iron formation, incluc ing two rather distinct types, one banded grey and black with silic and magnetite, the other banded red and bluish-grey or black, con sisting of jasper and hematite. The former variety sometimes passe into the latter, a few small bands of jasper occurring with the magne tite and grey silica. The black variety with magnetite is found on the northern and southern ranges, and the jasper variety in the central range; and the three ranges seem to be quite separate but run parallel to one another. Just why the ore should be different in ranges less than a mile apart, associated with very similar rocks, is not quite clear, but even the small jaspery parts of the northern and southern ranges are easily distinguished from the brightly coloured banded material of the central range.'[2]

'The Iron formation of all three ranges is very commonly crumpled and folded on a small scale, though the general arrangement of the banding maintains a fairly uniform direction, a little north of east, and in most cases the bands dip at steep angles or are vertical. Often the formation has been shattered, and the fissures filled by later white quartz, giving a very vivid, striking appearance to the rock.'[3]

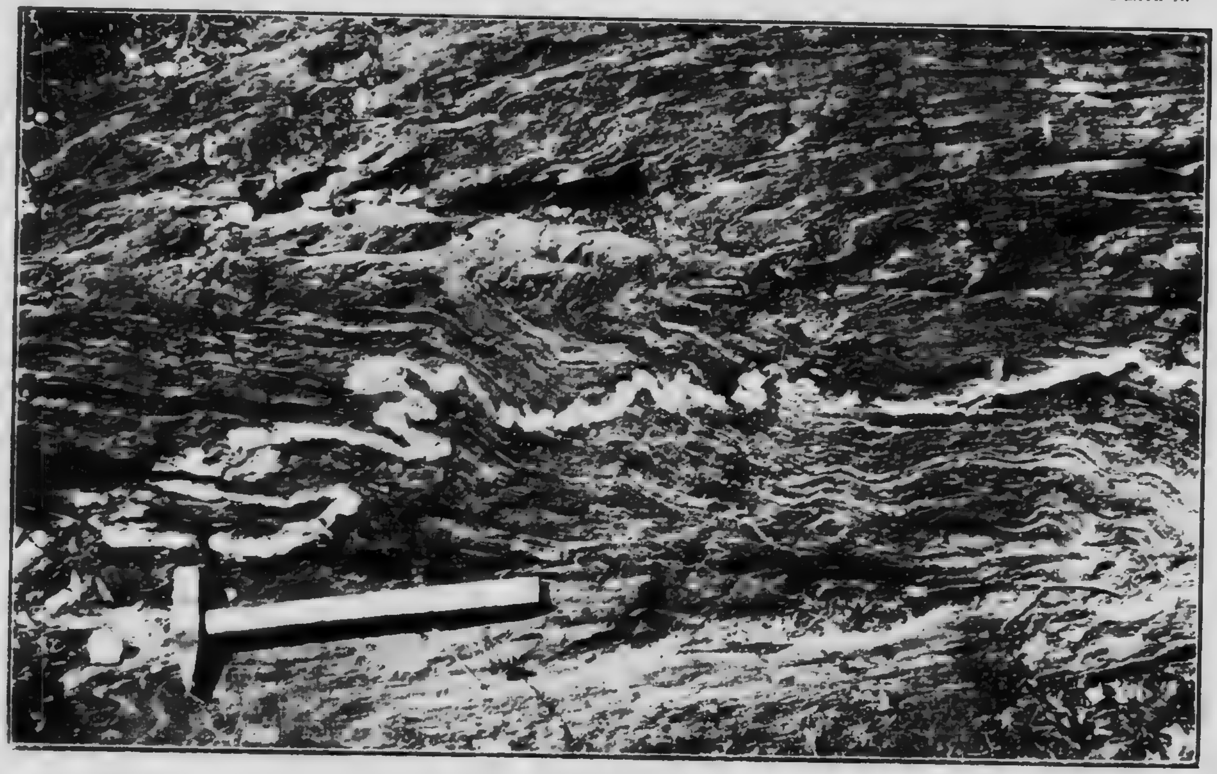
The Iron range rocks occur as bands within the larger areas of Keewatin rocks. The relative positions of the bands already recognized have suggested the nomenclature for the ranges adopted by Coleman.

The northern range has only been traced for about one mile in a general northeasterly direction on the north side of the Sturgeon river. Sometimes it outcrops beside the river, but usually sand and gravel terraces lie between the river and the principal outcrops.

The central range is found about three miles inland from Poplar Lodge, lies about three miles south of the northern range, and has been traced intermittently across a number of claims for about three miles.

[1] Coleman, 5 and 6; Moore, 18, 19, and 21
[2] Coleman, 5, p. 113.
[3] Coleman, 5, p. 114.

Plate II.



Banded Jasper on the iron range east of Poplar Lodge, on claim A. L. 116.

6618 p. 44

The southern range lies about sixty chains south of the central range at the west end, but is separated from it by steep ridges of greenstone and green schist. It has been traced intermittently for nearly seven and a half miles in a direction a little to the north of east.

Coleman suggests that the north and south ranges are each a narrow syncline enclosed in the grey and green schists of the Keewatin; while the central range may represent a number of parallel close folds, less vigorously compressed in the mountain building process. He regards it as possible that the ranges are the lower parts of greatly denuded canoe-shaped synclines. He notes, however, that the widespread muskegs and sandplains make it difficult to work out the structural relations completely enough to give definite ideas as to the attitude of the basin enclosing the formation.[1]

Other Iron Ranges.—East of the three ranges already mentioned are a number of other scattered outcrops of Iron range rocks. Most of these have been studied and mapped in detail by E. S. Moore for the Ontario Bureau of Mines. The most important outcrops of the formation are found at Lake Windigokan, at Still lake, and northeast of Watson lake.

The associated rocks are greenstones, green and grey schists, as on the other ranges. The Iron formation consists of banded silica similar to that on the other ranges. The iron-bearing rock is almost invariably interbanded with a dark slate or a hard slate-like schist, and in some cases is interbanded with an arkose.'[2]

Origin of the Keewatin Rocks.—Within the Keewatin area are found a great variety of rocks, more or less intimately related. The majority of those classed under the generic name of greenstones are massive igneous rocks, some of which were plutonic, some of which were volcanic flows. Many of the green schists probably represent greatly altered volcanic ash rocks, while others are undoubtedly derived from the metamorphism of basic eruptives. The carbonate schists may be metamorphosed quartz porphyry, rhyolitic ash rocks, or perhaps even arkoses. The origin of that portion of the rocks more directly associated with the Iron formation is even more

[1] For discussion of economic geology see page 137.
[2] Moore, 18, p. 136.

obscure. Probably much of the Iron formation itself is of secondary origin—but in the light of our present knowledge of the ranges, it is a subject that cannot profitably be discussed.

Structural Relations of the Keewatin Rocks.—The schistose rocks of the area are arranged in a series of parallel or subparallel bands, more or less persistent, and with a general strike which lies between east and northeast. Usually the structures are nearly vertical, but occasional variations up to a maximum of about 30° from the vertical are noted.

The massive greenstones show no schistose structure except at their margins. Here the schists are seen to bend around them, as if crushed against them, and often the greenstones themselves seem to merge gradually into the schists as if they were different metamorphic phases of the same rock.

The rocks of the Iron formation are frequently intricately folded, plicated, and crumpled, the plication and crumpling taking place in a nearly vertical plane almost normal to the plane of the folding. In their vicinity the folding of the schists is invariably much complicated. Much of the plication seems to have taken place after the introduction of the veins of pure quartz that traverse the banded ...ca rocks of the formation.

CROSS LAKE AREA.

This area covers about 150 square miles, and lies in the northeast corner of the area mapped. Cross lake is located near the southwest corner of the band of Keewatin rocks, while Summit and Marshall lakes are surrounded by them. The subjoined description of the rocks is taken from Parks' report for 1902.[1]

"The farthest north exposure is that observed on the Pawatik river, not far from its confluence with the Kapikotongwa. Practically the same rock is seen at the falls and at the portage next above. This example is very evenly banded, and much resembles that seen on the small island off the mouth of the Onaman river: the strike is E N E. and the dip 85° to the southeast. The rock is extremely fine grained and of a dark-grey to green colour. Under the microscope is seen hornblende in elongated individuals with their long axes parallel, and also parallel to the direction of the schistosity. Quartz, the only other important constituent, occurs in

[1] Parks, 25, p. 40.

still smaller grains, accompanied by a little sericite. The rock is a typical fine-grained hornblende schist. Similar rocks are seen on Height-of-Land lake, while on the river entering this lake whitish schists occur striking due east and west, and dipping 70° to the south. Under the microscope this rock shows a fine mosaic of quartz fragments, all much torn and broken. Larger corroded pieces of hornblende occur, in part altered to chlorite and other secondary minerals. Grains of pyrite and of magnetite are common, as well as bars and needles of apatite. The whole rock shows evidence of much alteration, so that its original nature is doubtful, but from the occasional occurrence of larger fragments of quartz with distinctly broken borders, the rock would seem to be a clastic. Farther up the river the same rock becomes more schistose, and is cut by veins of hard, glassy quartz containing large flakes of secondary mica. Before reaching the lake the rock is a hard fine-grained variety, striking east and west and dipping 45° to the south. This rock consists chiefly of quartz and secondary mica in less amount, and is well developed on the north shore of the lake above. On the next portage the strike is E 20° N. and the dip 45° to the S E. Two varieties are seen here: the typical grey quartzose rock and an example of the same nature, but with a small amount of basic material aggregated into dots which seem to consist chiefly of dark-green secondary mica. Along the shores of Marshall lake similar clastic quartz rocks of whitish colour alternate with the grey variety, both averaging E 10° N in strike.

On the shore of the marsh above Cross lake the clastic rocks give place to an altered eruptive, probably a diorite or a diabase. At the point where the river enters Cross lake the strike is E S E and the dip 85° N. The rock here is of a fine green colour with white blebs composed of deformed quartz individuals, quartz and secondary mica forming the bulk of the rock, which is decidedly schistose in structure. Just north of this point, with the same strike and dip, is a whitish rock very similar to the one already described. It consists of a mass of fine feldspar and quartz with a small amount of secondary mica, and other associated secondary minerals. In this example, however, microscopic examination shows feldspar individuals around which the fine-grained constituents present a distinct flow structure. A similar rock is seen on the south side of the northwest bay of the lake, striking a little north of east. Associated with this probable clastic in this locality

is a dark, massive eruptive, seen on the first point west the portage to the little lakes. Under the microscope this rock seen to be a diorite, with fairly fresh pleochroic hornblende in lar amount, while the plagioclase is much less abundant and large epidotized. Close to this rock, and probably an altered example the same matrix, is a dark massive, and to the naked eye, hom geneous or slightly mottled rock, which, under the microscop presents some interesting alteration phenomena. This example show a fibrous serpentine structure, and in fact it might be described as serpentine. The fibres run indiscriminately across the rather dis tinctly defined areas of the original minerals which, strange to say show the outline and manner of alteration of olivine, although thi mineral was not met with in the neighbouring less altered rocks Much magnetite appears in large grains in the zones surrounding the altered ferro-magnesian mineral, while within the latter it is arranged in the finest specks apparently along lines intersecting at right angles.

West of the above rock, but in close contact, is a very heavy diorite, almost amphibolite. On the north side of this bay is a good example of sericite schist, the most extreme alteration product of the clastic rocks already described. The strike is N 50° E. and the dip 70° to the southward. Along this north shore examples of the entire series may be found, from sericite schist to the hard, grey, uniform flecked examples, in some cases so destitute of other minerals as to deserve the name of quartzite. Veins and stringers of hard, barren quartz traverse these rocks in directions generally parallel to the bedding.

The eruptive diorite above mentioned forms the north half of the point stretching into Cross lake from the east, and is the rock in immediate contact with the Laurentian rocks, which form the southern half of this point. The line of contact is marked, so far as the Keewatin is concerned, by a bluff of this massive diorite standing almost vertical, and striking nearly due northeast.

This contact is also seen on the long bay stretching to the south-east of Cross lake. At the narrows east of the high granitic hill already mentioned as occurring on the south shore, is a heavy basic eruptive becoming schistose in part. Under the microscope is revealed a structure quite similar to that presented by the massive rock from the east end of the lake. Similar rock, finer in grain, is seen half a mile farther east. On the north side of the narrows

at this point is a porphyritic schist with blebs and patches of quartz cutting the formation at a low angle. The rock shows fine secondary mica and large fragments of bluish quartz more or less drawn out in the direction of schistosity, which is N 60° W with a dip of 75° to the northeast. Towards the north this rock is followed by a basic example which also shows lamination for about 10 feet near the contact. At the foot of the bay the rock, evidently of eruptive origin, is plainly schistose, and has all the appearance of a rock subjected to extreme dynamite metamorphism. (Strike E N E. dip vertical.)

At the extreme southeast angle of the bay the rock is quite massive, with seams of quartz showing a banded structure and containing broken needles of tourmaline and other minerals, proving that even the quartz bands had been dynamically affected after formation. A proof of this is also seen in the rock which, under the microscope, shows highly pleochroic hornblende as the chief constituent, certain individuals of which are distinctly bent. This hornblende is possibly of secondary origin, as much of it shows a fibrous appearance, while the other constituents are so altered as to be indeterminable.

Westward from Cross lake the portage to the first small lake shows white and grey clastic schists at either end, while the central portion is occupied by schists of altered dioritic aspect, which in a more or less schistose condition occupy the south shore of the lake. On the north side is a rock resembling a gneiss, and presenting a distinctly laminated appearance, with fibres dipping 70° to the northeast. The strike is almost imperceptible, but seems to be E 10° S. Under the microscope are seen large anhedra of quartz with their long axes parallel; while between lie smaller grains of quartz, orthoclase, and microcline, and bands of brown biotite are arranged in parallel position. The rock differs from ordinary biotite gneiss in that there is no *lamination*, but a *fibrous* arrangement of the constituents. I must regard this rock as a gneiss, although its relation to the schists makes it necessary to class it as Keewatin.

In the Keewatin[1] region so far considered it would appear, therefore, that a series of schists, in all probability of clastic origin, lies on the north flanks of a lesser mass of eruptive rock of a basic nature in various stages of alteration. All the dips observed on the Pawatik

[1] The name Keewatin has throughout been substituted for the name Huronian used in the original manuscript.

river, on Height-of-land lake, and on Marshall lake are to the south on Pawatik river 85°, on Height-of-land lake 70°, and on Marshall lake 45°. On the other hand dips to the north are seen on Cross lake. It is, therefore, likely that Height-of-land lake, with the river above and Marshall lake, occupy a syncline in a series of strata of which the lower examples are of eruptive nature and the higher members clastic.'

Mr. Harvie traversed the area in 1908, and also surveyed several small lakes east of Cross lake, locating more accurately the southern boundary of the Keewatin. He did not have the opportunity of examining the whole area in detail, but his observations tend to confirm those of Parks.

The writer, who, however, has not visited the district, ventures to suggest that to the Keewatin should be assigned only the more basic rocks of the region and the associated schists, some of which Parks considers to be of clastic origin. Of the basic schists the dominant type seems to be an amphibolite containing hornblende and quartz. Some of the rocks included in this area and mapped as Keewatin are undoubtedly gneisses, while others are distinctly acidic in character. Some of these are interbanded with the amphibolites, and cannot be separated from them except by detailed mapping. In other cases the relations to the amphibolites are obscure. It may be that these rocks form only a relatively thin cover over a granite batholith beneath, and that they are the extreme metamorphic stages of a series of Keewatin rocks, and owe their acid character to contact metamorphism. In many respects they resemble rocks found at the margin of the Keewatin area to the south, and in some respects some of the more acid bands resemble rocks found in the Laurentian areas south of the Blackwater river, which are classified with the Laurentian because they are not well enough known to be separated from it in mapping.

In brief, these acidic schistose rocks, particularly in the Summit-Marshall Lake region, occupy a very doubtful position between undoubtedly Keewatin and undoubtedly Laurentian.

ROUND LAKE AND CARIBOU LAKE AREA.

In the northwest corner of the area mapped there are about 100 square miles of territory underlaid chiefly by basic rocks, usually schists, which may be classed as Keewatin. They are known to outcrop on the east shore of Caribou lake, to be continuous along a chain of lakes and streams from Caribou lake to the Pikitigushi

river and to outcrop at several points along that river, more especially just north of Round lake. We do not know how far they extend east of the Pikitigushi, though no outcrops were reported from the valley of the Little Jackfish river, about sixteen miles east. Neither the northern nor the southern boundaries have been traced, though the southern boundary is known at one point on the east shore of Caribou lake. The area given above as 100 square miles is based on the assumption that the southern boundary does not extend far below the straight line between Round lake and Caribou lake.

The rocks near the contact with the Laurentian are highly crystalline basic schists, chiefly amphibolites. At the upper part of the northeast arm of Caribou lake light coloured chloritic schists are found, and interbanded with these greenish schists are bands and stringers of quartz. On the portage leading northeast from this bay there is also a long ridge of granite porphyry, showing schistose structure on its margin, the green schists occupying low ground on either side of the porphyry ridge.

Greenstones, porphyries, and green schists, the latter containing quartz stringers and masses, are found to extend all the way to the Pikitigushi. At one point about five miles west of the Pikitigushi, the best exposures of pillow lavas to be found in the whole district were noted. The lava is fine textured and green in colour because of chlorite. Originally it was probably a basalt. Other exposures of green schists, greenstones, and pillow lavas are found in the valley of the Pikitigushi.

The southern limit of this Keewatin area probably lies not far from Lake Nipigon, as there is a small outcrop of greenstone, showing traces of schistose structure, at the first falls about eight miles from the lake. The bed-rock in this vicinity is nearly all obscured by post-Pleistocene lake deposits, and the extent of the Keewatin rocks cannot be accurately determined.

Some small areas of Iron formation are known to occur, interbanded with the Keewatin of this area. So far as investigated they are not of economic importance. One of these just north of Round lake was found by Moore to consist of recrystallized chert and magnetite.[1] Those which are known are too small to show on the scale used on the map sheet which accompanies this report.

The prevailing strike throughout the region is east and west.

[1] Letter to the author.

RELATIONS OF LAURENTIAN TO KEEWATIN.

Along the boundaries of all the Keewatin areas the relation between the Laurentian and the Keewatin are well shown, particularly in those localities where the rocks have been laid bare by streams and waves. Descriptions of one locality, with slight local modifications, are applicable to all. The relations are particularly well shown on Caribou lake at the south edge of the northwestern Keewatin area, and along the northeastern shore of Lake Nipigon at the northern edge of the large eastern area of Keewatin. This latter locality is easily accessible, and being typical is here described. Coleman visited the locality in 1907, and published a description of this contact in 190 ; although the writer has examined the district in the field and has studied the contacts in some detail, he does not find it necessary to modify Coleman's description in any respect.

After describing the character of the shore exposures northward from the Sturgeon river as far as the creek from North Wing lake where red granite begins, Coleman describes the shore section as follows:—[1]

'The Keewatin rocks here include hornblende porphyrite, ordinary green schist, and obscure amygdaloids, through which the coarse red granite has pushed up, carrying off blocks and sending dikes of various kinds and sizes into it. The boundary between Laurentian and Keewatin is very sharp in most cases, and is emphasized by the difference in colour, pink or flesh-red in contrast with dark green. The batholith of granite has had little effect on the sharp-edged blocks of greenstone near their source, but some smaller bits, probably carried farther and digested for a longer time, show blurred outlines and have been partly absorbed.

There is an interesting assemblage of eruptive rocks near the mouth of the small river, where not alone the coarse granite and dark greenstone, but dikes of at least two kinds of granite, finer in grain and paler in colour than the batholithic mass, penetrate the greenstone; a wide dike of diabase, probably (post) Keweenawan, cuts the granite, and tiny dikes of felsite appear in the diabase itself. There are then eruptives of at least four ages, from Keewatin to post-Keweenawan, within a space of 100 feet on the clean ice-smoothed and wave-washed shore. The contact of granite and the older rocks is clearly eruptive, with no blurring of boundaries or

[1] Coleman, 6, pp. 154-157.

dragging out into gneissoid forms at the southern edge of the Laurentian batholith just described. Going north along the shore, however, the patches of greenstone in the granite appear to be more and more rolled out and elongated, the granite becomes grey, as if greenstone had been absorbed, and an indistinct gneissoid structure is noted.

The long peninsula of Livingstone point now intervenes, with a sheet of diabase hiding the older rocks for a mile and a half from its end. Rounding the point some Keewatin greenstone and breccia show beneath the diabase for a short distance, but are covered again. Entering the bay Keewatin schist of a green-black colour appears on islands, interleaved with thin seams of granite, and this intermixture continues as far as points near the mouth of the Onaman river, where the relationships were somewhat closely studied.

On certain islands near the river mouth the Keewatin consists of amphibolite, porphyrite, or greenstone, and green schist, in every stage of intermixture with granitoid gneiss, which no longer has the appearance of eruptive granite; and no more instructive display of the mode of production of Laurentian gneiss or a 'basal complex' could be desired. Unchanged masses of amphibolite an acre or two in area may be found on some of the islands, penetrated by small lighter coloured dikes of more than one age. Nearby the greenstone is brecciated, the sharp-edged blocks cemented by thin sheets of granite. At other places both greenstone and the granite dikes have been drawn out into long bands with a schistose structure having lighter and darker layers. Finally one finds them passing into rather coarse gneiss, banded with lighter and darker shades, but with no distinguishable greenstone or green schist left. This greyish gneiss is itself cut by dikes of red granite or of pegmatite, later effusions of the general magma.

At several points on the small islands *lit par lit* injection is beautifully illustrated, bands of green schist and granite alternating, of every dimension down to a millimetre (one twenty-fifth of an inch) or less. On some surfaces the banding shows two shades of green along with the pink of the granite. Thin sections prove that the darker green bands are diorite schist, consisting of plagioclase and hornblende, the paler green bands quartz-epidote rock, while the granitic bands consist of quartz, plagioclase, microcline, and hornblende. All the minerals tend to be crushed and strained, perhaps

because of later movements in the region after the granitoid gne ad completely solidified.

In many places also the granitic materials have augen stru res, with rows of pinkish crystals, all oval and tailed out at t ls, suggesting movement since solidification.

Frequently there are two stages of the process of interbandin In one case a band of coarse granitoid gneiss 8" wide w enclosing a narrow band of dark green schist of equally coar , and carrying off also fragments of very fine-grained gre ial with thin seams of pink. Here the earlier injected mass had been swept away by fresh granitoid magm from beneath, of a more fluid kind, capable of dissolvin the basic materials of the Keewatin more completel is of the granite belonging to this laccolith (bath lith that it contains a large amount of plagioclase (olig clase), and should perhaps be called a granodiorite rather tha granite, though its flesh colour is characteristic in most places. I is very quartzose, contains muscovite, as well as biotite and olig clase, with orthoclase and microcline as the feldspars.

Dikes extending into the Keewatin are finer grained, sometime flesh coloured and sometimes grey. A thin section from a flesh coloured dike has the same constituents as the main granite, though with less biotite and more muscovite. A thin section of a grey dike rock has a fine grained groundmass of the same minerals as the other, but with more biotite, including, however, phenocrysts of plagioclase, often Carlsbad twins.

The adjoining Keewatin schist consists of hornblende, plagioclase, and a little magnetite, probably minerals rearranged from some basic eruptive like diabase.'

LAURENTIAN.

About three-fifths of the area mapped is underlain by a complex series of granites and gneisses classed as Laurentian. Around the borders of the large areas which are covered by the trap sheets the Laurentian series also outcrops; the dissection of the sheets has disclosed small fragments of the crystalline floor at many points. It seems probable that all of the post Huronian rocks of the region rest upon Laurentian, except in the few places where the Keewatin rocks are known to pass beneath the younger overlying series.

ROCK TYPES.

Parks has distinguished four principal types of rocks in the large areas which occur in the southeast quarter of the region

(1) A typical reddish medium-textured gneiss consisting of quartz, orthoclase, and biotite. In part the biotite is replaced by muscovite, and occasionally by hornblende.

(2) A fine-textured dark-grey variety resembling a biotite schist It consists of numerous flakes of black biotite, replaced in part by hornblende, white orthoclase, a little plagioclase, and considerable quartz. Small quartz veinlets are often found in this type of gneiss, running parallel to the foliation; occasionally other veinlets running nearly normal to the structure are noted.

(3) Unaltered granite, chiefly biotite granite, with pink or white orthoclase. This rock is identical in mineral composition with the first type of gneiss, but does not show foliation. It probably passes into the first variety by imperceptible gradations. With the second variety, the grey gneiss, it is in sharp contrast, showing the contact relations of a younger igneous rock.

(4) A fourth variety, typically developed in the country lying between the Blackwater river and the chain of lakes to the south, is a fine-textured rock containing a good deal of quartz in small anhedra, and a somewhat glassy feldspar in small amount. It is characterized by the presence of needle-like crystals of hornblende. Locally the hornblende increases in amount and the rock becomes a 'basic gneiss,' dark in colour; and much altered near the surface into a crumbling mass of secondary micas, epidotized plagioclase, kaolinized orthoclase, and quartz. The extent of these rocks is unknown.[1]

This classification may be extended to include not only the gneisses and granites of the southeast part of the area, but also those west of the Nipigon river, and those north and east of the lake.

West of the Nipigon river pink biotite granite, grading into granite gneiss, is the prevailing rock. In the northeast part of the region Parks found the two prevailing types to be a more or less banded older grey variety of gneiss, and a younger pinkish granite.

In addition to the minerals referred to above in the classification, the writer found that microcline was a very common constituent of

[1] Parks, 23. pp. 23-24, abstract.

the granites and light coloured gneisses, in some cases to the c
plete exclusion of the other feldspars. Such accessory minerals
sphene, apatite, and magnetite, are only found occasionally. Epi
as a secondary constituent has been noted. In a few locali
secondary hematite occurs in gneisses in small specks and flakes;
the Black Sturgeon Lake region in considerable amount.

While the biotite granites and gneisses are the two common
rocks of the region, occasional areas are found in which hornble
is also present as a primary constituent in quantity at least equ
to the biotite, so that the rock becomes a hornblende-biotite gne
or granite. Occasionally this biotite may be altogether wantin
when the rock becomes a hornblende gneiss or granite. Such
gneiss occurs east of the portage leading into Black Sturgeon la
from the north. The rock consists of large crystalline masses
fibrous hornblende with much quartz, and small amounts of feldsp
and magnetite.

The texture of the gneisses and granites varies from very coar
in certain pegmatitic varieties, to coarse in the normal types, and t
very fine grained in some varieties. Some of the gneisses south o
the headwaters of the Blackwater river are so fine textured that th
individual constituents cannot be distinguished in the hand speci
mens.

The texture of the massive granites varies in the different areas
and in different parts of the same area. Usually it is coarse; in
some localities, where dikes of granite are intrusive in the other
rocks, the structures may become pegmatitic. Parks mentions an
occurrence near the Jackfish river, where the orthoclase crystals
were about 10″ in diameter. The granites differ among themselves
so little either in texture or composition over large areas, that
descriptions of the individual occurrences in the various areas are
unnecessary.

In one locality, at Nipigon House and in that vicinity, there is a local variation of what is probably one of the younger granites. The rock, a red granite porphyry, is characterized by the small translucent anhedra of quartz in a pink feldspathic groundmass. There are also idiomorphic orthoclase crystals, now usually kaolinized. The fine-textured reddish groundmass consists of small quartz grains and altered feldspathic material. The rock also contains a small amount of hornblende, but the greater proportion of the minerals present are the two first named. The relation of this area

of granite porphyry, some 10 square miles in extent, to the other Archaean rocks of the region could not be ascertained, because of the overlying cover of later rocks.

ORIGIN AND STRUCTURE.

The gneisses and granites are portions of huge batholithic masses which had forced their way upward into an overlying cover, of which little is known. The structural details of the region have not been determined for the area accurately enough to enable us to represent the several batholiths that are known to occur. In general, they seem to have a trend in a direction about N 15° E, which is also the direction in which the Keewatin rocks are folded, as if the batholithic masses were in the form of elongated domes. It seems probable that the district presents the basement of a former mountain range, greatly degraded, and that the direction of the major trends in this range was in general parallel to the strike of the structures.

It is probable that the movements in the granites did not take place solely while the rock was in the form of an uncrystallized magma, but rather they continued through at least a portion of the period of cooling, and probably the movement did not cease until after the rock was completely solidified. Evidence of protoclastic structure can be seen in nearly all the coarser gneiss areas, though it is not so evident in the bodies of younger granite. The structure is marked by 'the presence of more or less lenticular, broken fragments of large feldspars in a fluidally-arranged mass of smaller allotriomorphic feldspar grains, with quartz stringers and a few biotite flakes.' The quartz also is occasionally crushed and broken. This fluidal arrangement, which constitutes the foliation of the rocks, is seen in every stage of development, there being an imperceptible gradation from perfectly massive forms through the more or less gneissic varieties to thinly foliated gneiss.

Some of the basic gneisses probably represent highly metamorphosed portions of the cover, or rather are new rocks whose constituents in part were derived from the cover, and in part from the granite magma. It has not always been possible to distinguish these from the others. In the case of the grey gneisses of the region, which are undoubtedly older than some of the lighter granites and granite-gneisses, Parks considers that they may represent a series

of rocks parallel to Lawson's Couchiching. The relations of grey gneisses to the Keewatin has not been satisfactorily est lished, though they appear to be older.

Lower Huronian.

A series of conglomerates classed as lower Huronian are fou associated with rocks of the Iron formation in the Sturgeon Ri valley, and to the south of this near the other iron ranges. Usua it occurs as narrow bands parallel to the other formations. Ne the Poplar Lodge iron ranges the conglomerate is found only small areas. In the Windigokan region it occurs in a nearly co tinuous band, usually varying from 200 to 500 feet in width, for distance of nearly fifteen miles.

Small bands of a conglomerate containing only quartzite pebbl were found in the Keewatin areas between Round lake and Caribo lake. No Iron range rocks were noted in the vicinity, though the may be present. These areas are too small to be represented on th map.

ROCK TYPES.

The principal rock belonging to this series is a conglomerate The types of rocks represented by the pebbles and boulders o the conglomerate are similar to those of the region, and almos all are represented, including not only the different Keewatin series, but also granites and gneisses of the Laurentian. The list o included fragments includes aplite, granite, gneiss, diorite, felsite porphyry, greenstone, green schists, jasper, and other varieties of th banded silica of the Iron formation, slate, and vein quartz. In size these fragments vary from the smallest pebbles to boulders nearly 2 feet across; the large blocks are rare. Usually the fragments are well rounded, but some angular fragments and plates occur. Often they are closely crowded together; occasionally they are scattered through a large amount of cementing material. The matrix of the conglomerate is a somewhat recrystallized arkose material containing angular fragments of quartz and feldspar. The metamorphism to which the rock has been subjected has given rise to a pronounced schistose structure which is best dev ped in the matrix, where it may often be seen to bend around the constituent pebbles. Sometimes the softer pebbles have been drawn out into

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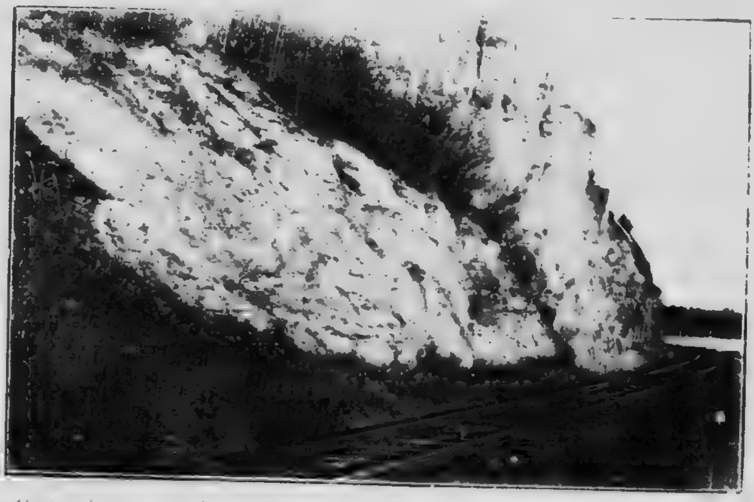
PLATE

Sheared Huronian conglomerate on the south shore of Paint lake, headwaters of the Namewaminikan river, about twenty miles east of Lake Nipigon.

PLATE X.



Contact between overlying diabase and underlying Keweenawan sediments at Red Rock, near mile post 66, on the Canadian Pacific Railway, west of Schreiber station.

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lenses, or have been dented or impressed by the harder ones during the process of metamorphism. The harder pebbles usually have not been altered in shape. Occasionally the rock presents a banded appearance owing to the distribution of the pebbles in the matrix, bands with a few or small pebbles alternating with layers in which they are more abundant.

Associated with the conglomerates are some bands of dark grey slate and some dark coloured arkoses, in both of which the schistose structure is accordant with that of the adjacent rocks.

The arkoses consist largely of quartz fragments in a matrix of dark green chloritic material and smaller quartz particles. Feldspar more or less kaolinized is also present. In a few instances small flakes of jasper were noted in an arkose, but this occurrence is rare. Some of the arkoses are found interbanded with the Iron formation, and possibly should be classed with it. On the other hand, some of the arkoses are closely associated with the lower Huronian conglomerate, and also contain a few jasper fragments. For this reason they are classed with the conglomerate.

The order of succession of the series has not been established.

ORIGIN.

The whole of the lower Huronian rocks found are sediments of one kind or another. The diverse character of the fragments which they contain indicates that they could not have been laid down until profound erosion of the Keewatin rocks, and of the Laurentian rocks which had penetrated them, had taken place. Previous to the erosion the Keewatin had been subject to intense metamorphism. The erosion interval must have been a long one, for the fragments of waste from the earlier series now preserved in the conglomerates, form beds several hundreds of feet in thickness and many miles in extent. The time break between the Keewatin and Laurentian on the one hand, and the succeeding lower Huronian on the other, must have been of very long duration.

The lower Huronian conglomerate is of importance geologically, as affording a well-defined horizon for the subdivision of the Archæan. It is also of practical importance in the field, since the rocks are easily recognized, and also afford one of the best guides for working out the structures of the iron ranges.

KEWEENAWAN.

The rocks classified as Keweenawan are represented by a of horizontally bedded sediments ranging from basal conglome through sandstones and shales to dolomites. It is probable tha formation was once very widely distributed over the whole area. the present time numerous small outlying masses are found at points in the Lake Nipigon basin, particularly around the shor the lake. The outcrops found are usually the edges of beds w are preserved under a diabase flow of later age. In the south corner of the district there are large areas of these rocks form the bed-rock in the basins of the Poshkokagan, Nonwatin, and B Sturgeon rivers.

Within the boundaries of the map sheet no continuous sec has been measured, but by correlating data obtained from numer small sections the relative positions of all the members of the se can be established. The best sections of the series lie south of area discussed in the present report, not far from the main line the Canadian Pacific railway. Sections of the lower beds are fou under nearly all the diabase mesas which form prominent topog phic features on the east and south shores of Lake Nipigon. A f small remnants of the basal series are also found in the upper vall of the Wabinosh and Kaiashk rivers, preserved in the bottoms of valleys cut in Archæan rocks, and exposed again by the dissection the overlying trap sheet. Excellent sections of the upper memb of the series occur in the valleys of the Poshkokagan, Nonwatin, a Black Sturgeon rivers.

BASAL CONGLOMERATES.

These rocks have been found only in a few special localitie descriptions of which follow:—

About a mile east of the deep bay on the middle of the east shor of Black Sturgeon lake, a few feet of basal conglomerate are foun resting directly upon granitoid gneiss. The lowest bed is only feet in thickness, and is a greenish mottled conglomerate containin many large and small pieces of quartz, numerous more or les angular fragments of feldspar, and a few sub-rounded small boulders of gneiss. The quartzose cement is tinted green by some ferruginous silicate. Overlying the conglomerate are 4 feet of mottled greenish sandstones or grits. Above this are a few feet of pink sandstone.

At this locality the series dip 11° to the southeast and strike N 62° E; the inclination is probably due to the slope of the surface of the underlying crystalline ridge on which they were deposited.

About eight miles north of this, and half a mile east of the small lake on the portage north from Black Sturgeon lake, the basal conglomerate beds are again found in actual contact with the underlying Archæan. Here also the pebbles are rounded or subangular, and include fragments derived from the underlying rocks. At this point the conglomerate grades upward into a coarse grit consisting of subangular grains of white quartz in which there is a small percentage of large angular fragments of a nearly transparent quartz. Twenty-five feet above the grit bed, the interval being obscured by loose debris, are several feet of the fine-textured pink sandstones.

The only other locality in which the basal conglomerates have been noted is on the west shore of Humboldt bay, opposite Knob island. Here some loose blocks of a very similar conglomerate, with a dark-green siliceous cement, were found, but the rock was not seen in situ. In this locality the underlying rock is Keewatin green schist, and the cement material of the conglomerate undoubtedly owes its dark-green colour to the presence of chloritic waste derived from the Keewatin.

These basal conglomerates are not widespread in the Nipigon basin and may be wanting from the base of the series, since in several localities the finer sandstones have been found resting on the Archæan.

SANDSTONES.

The sandstones of the series vary in texture from coarse grits to fine grained sandstones. Some beds are found to be quite hard, and occasionally they may become quartzites, while others are soft and friable. As a general rule the soft and friable beds belong to the upper part of the sandstone series. The colours of the beds differ in different localities; many of them are white, others are various tints of green or pink, while red sandstones, which owe their colour to the presence of a small amount of ferric oxide mingled with the quartz grains, are very widespread.

The typical hard white sandstone consists of uniformly rounded grains of quartz in a siliceous matrix. The matrix itself consists of minute quartz grains and secondary silica. The pink friable sandstone consists of well rounded quartz grains and a small amount

of more or less decomposed orthoclase, the siliceous cem material being stained with ferric oxide. Coleman found one light coloured sandstones, from near Kama, just south of the mapped, to consist of about 'three-fourths quartz grains and fourth of other materials, often somewhat turbid in appearanc cluding orthoclase, microcline, and plagioclase, and a certain an of some carbonate. There were also concretionary spherules, up of microcrystalline silica and a carbonate. The quartz grain often well rounded, and have been enlarged by a growth of cl quartz, until the individuals met and formed an interlo mosaic.'[1]

Sometimes transitional beds are found where the sandston this series gradually merge with the shales and dolomites of upper portion of the series. Occasionally thin beds or layers of s lenticular shaped masses of sandstone are found in the lower por of the beds of shale in the district around Black Sturgeon lake river.

The beds of sandstone are nearly always found in a horizo attitude, or only slightly inclined. Occasionally the inclination the beds may be due to local faulting and tilting. More freque it is attributable to the original slope of the surface upon which lower beds were deposited.

Within the bounds of the map sheet a number of small outly masses of this sandstone series are found at several points arou the shores of Lake Nipigon. These are: near Nipigon House, w of Castle island, on the shore of the south peninsula of Ombabi on the north shore of Humboldt bay, on both sides of Livingst point. Large areas are found in the Black Sturgeon Lake regi and west of it around Little Sturgeon and Sucker lakes. In t valley of the upper Spruce river, near the boundary of the area, t lower beds are highly ferruginous red sandstones carrying large a small angular fragments of white quartz. In some cases fragmen of quartz fully 3" across were noted, occurring only in scatter pieces. Grey friable sandstones are found in the country betwe Little Sturgeon lake and Sucker lake. Outlying areas also occ near the southern part of the sheet in townships of Boot Purdom, Ledger, and east of Ledger along base of a high escar ment. South of the area mapped the sandstones are found near th

[1] Coleman, 6, p. 160

base of the stratigraphic column which constitutes the rock series in several prominent lava-capped mesas lying near the Canadian Pacific railway. The upper part of the series, shown in section in the cliff fronts of the mesas, is usually shales and dolomitic limestones.

It is difficult to determine the thickness of the sandstone portion of the formation within the boundaries of the map sheet, as no continuous section suitable for measurement was noted. In many cases the writer is inclined to believe that the sandstones are merely the shoreward ends of beds which gradually pass through arenaceous shales, to shales and dolomites, as distance from the old Keweenawan shoreline increases. In the district around Black Sturgeon lake the writer estimated the maximum thickness as probably about 100 feet. In correlating the various outcrops as now exposed, they seem to range themselves on either side of a northwest trending ridge of gneiss upon which they rest unconformably, and from which they dip outward on both sides. After a period of erosion, previous to which the crystalline ridge may at one time have been completely covered with the sandstones, the invading trap sheets of a later period more or less disturbed these sandstones, in some places large masses were caught up into the traps, and many local variations in the attitude of the beds were produced. The relationships of the various beds are still further complicated by what appears to be a well-developed fault along the southwest face of the crystalline ridge mentioned above.

In many of the outlying areas the entire thickness of the sandstones between the crystalline basement and the overlying trap cap can be seen and measured, and this thickness varies in different places from 5 or 6 feet to about 100 feet. There is no means of ascertaining in these cases how much of the upper portion of the beds was removed before the trap came into its present situation.

SHALES.

Shales are frequently found in the basins of the rivers tributary to the Black Sturgeon river. They are variable in colour, ranging from dark grey, almost black, to several shades of red, brown, and pale green. The red and the green shales are the most abundant. Some of the red shales are spotted with small green or yellow spherules, or occasionally with patches of white material. In general it may be said that the shales are found beneath the dolomites, but

the lower layers of the dolomitic series are often separated by sh partings.

No analyses have been made, and their composition is uncert The darker coloured shales are usually free from carbonate some of the light coloured varieties contain a small amount of cium carbonate. In some localities it is possible to separate sh and dolomites, but in general the two are so intimately associa that they have to be considered together.

In one locality there was found a thick bed of material related the shales, that requires special mention. In the valley of the up Spruce river, conformably overlying sandstones, are 30 feet of d blue-grey compact clay slate, occurring in thin beds, but so coher that the rock breaks into large angular blocks. The surfaces these slabs frequently show large and small reticulated mud-crac No fossils were found. Some of the beds are coloured reddish, a the grey tints of different beds vary slightly, so that, on close insp tion, the cliff face presents a finely banded appearance. Overlyi this series of sedimentary rocks are 14 feet of trap. Where t trap comes in contact with the clay-slate the latter has become mu altered, and is of a red-pink colour. The whole series (sandston and shales) dips 4° to the east and strikes nearly north and sou Farther northeast, and hence geologically higher, there are occasion exposures of arenaceous dolomitic shales in the bed of the stream.

DOLOMITES.

The dolomites are the most important members of the series, n only because of their extensive distribution, but also because th make up the greater portion of the total thickness of the series. T beds vary in thickness from a few inches to sometimes 5 or 6 fe In texture the rocks are almost invariably fine grained, occasional slightly crystalline, and usually break with a more or less conchoid fracture. In colour they vary from dark red, almost brown, throug red, and various shades of green and greenish grey, to almost whit Some beds of the red variety are found containing small green yellow spherules, the character of which has not been determine Some of the beds of white dolomite are found streaked and splashe with red in a manner that tends to make the stone very ornamenta

In general, the localities in which outcrops of these rocks ar accessible are more or less dissociated. It has not always bee

possible to make satisfactory correlations, and it thus becomes necessary to describe a number of isolated localities.

Green Dolomites. Near the northeast angle of Chief bay there is a small area of greenish fine-textured argillaceous dolomite, in beds from 3" to 12" thick. In places the rock is streaked with red; it is fine textured and shows conchoidal fracture. The beds at this place are probably only a detached remnant lying between two trap sheets. An analysis cited by Bell[1] shows 38·5 per cent insoluble siliceous and clayey material: the soluble portion is calcium and magnesium carbonates in the ratio of about three to one.

Two miles southeast of this, near Tchiatang bluff, but on the north shore, an area of almost similar dolomites outcrops along the bay shore. Dr. Hoffmann's analysis of a specimen from this locality gave: calcium carbonate, 27·7 per cent; magnesium carbonate, 27·9 per cent; insoluble, 40 per cent; about one-third of the insoluble material was clay, and two-thirds silica.

A mile farther east, at the base of a bluff beside Willow creek, on the east side of the point, beds of an olive green dolomite, about 6 feet in all, outcrop from beneath a trap sheet about 125 feet thick (to the top of the bluff).[2] It is possible that this is a continuation of the other exposures found farther west; the outcrops are obscured by forest growth and the cover of drift.

Ten miles southeast of this, on the west side of McIntyre bay, similar dolomites cover an area several square miles in extent. The lower beds of the series, exposed in a creek bed two miles southwest of the bay, are green-white-brown mottled, earthy in appearance, and from 1" to 4" in thickness. The upper beds are compact, fine textured, pale green tinted, and sometimes 18" in thickness. The series dips at an angle of about 5° towards the northeast.

Fragments of similar rocks were found near the foot of South bay in the drift, but no further outcrops of these rocks were found in situ.

These green argillaceous dolomites are thus found to form a narrow belt about eighteen miles in length, running parallel to the axis of the ridge of Archaean rocks which outcrops here [illegible]

[1] Bell, 3, p. 362

[2] The outcrop at this locality is too small to show on the [illegible]

the country lying between Black Sturgeon lake and McIntyre Near the north end of Frazer lake some rocks occur which are i mediate in texture and appearance between the green dolomite the red dolomites. The extent of the area is unknown, and have not been shown on the map.

From the texture of the lower beds of the dolomites, inferred that they are either now lying conformably above stones adjacent to the Archæan, or that they have been lifted a conformable position by the intrusion of trap sheets. In some they seem to be caught up between two sheets of trap.

It is possible that the valley of the Kabitotikwia river, and basin occupied by Chief bay and the west part of Kainshk bay, ma underlain by these dolomites. The trap ridges are found on ei side, but no outcrops have been found in the basins on accoun the presence of glacial deposits.

In the Willow Creek locality a trap sheet is found overlying dolomites. On the east side of Chief bay similar dolomite app to rest conformably upon a sheet of trap. The surface of this sl presents a reticulated network of minute cracks filled with a li coloured mineral, presumably a feldspar. The texture is comp and very fine grained. No trace of vesicular structure nor weathering is visible. Within a quarter of a mile a trap sheet r 175 feet higher than the dolomite. Hence it appears very proba that the dolomites along this shore are merely a thin sheet cau between the two trap sheets, the lower being in this locality int sive, and the upper possibly extrusive. The same relations may h for the area of dolomites on McIntyre bay. Traps with a fine textu and a reticulated cracked surface are found close to the dolomit the surface dipping in a direction which suggests that it pas beneath them. On either side there are trap ridges with steep a cliffed fronts, jutting out into the bay as points. These latter pro ably represent the upper sheet in the vicinity of Tchiatang bluff. McIntyre bay the two rocks have not been found in actual supe position.

An extensive section of green dolomites is exposed in the gor of the Spruce river near the base of a trap-capped escarpment, a about two miles west of Little Sturgeon lake. Outcrops are foun only in the bed of the river, and their extent is unknown

Ferruginous Dolomites.—In the basin of the Black Sturgeon river, covering an area of about 120 square miles within the boundaries mapped, are a series of highly ferruginous red dolomites and associated shales and sandstones. They are also found in the valley of the Nonwatin river, and smaller areas, usually protected by an overlying trap sheet, are found in the vicinity of Magee and Frazer lakes, and also in the township of Ledger and north of this.

West of Black Sturgeon lake and river this series of rocks forms a nearly continuous escarpment; south of Eskwanonwatin lake the escarpment lies near the river. On the intace of the escarpment there is a section of about 400 feet vertically, nearly 200 of which appear in a cliff, the balance being obscured by a talus and loose waste. The beds appear to dip slightly to the southwest. The nature of the lower beds is uncertain, though some of them are probably sandstones. The upper beds are shales and dolomites. Overlying these dolomitic rocks is a trap sheet whose thickness varies considerably in different localities. The Black Sturgeon river, through the greater part of its course between Black Sturgeon lake and Nonwatin lake, runs in a shallow gorge cut in these dolomites. The section shows fine-grained indurated red dolomites with shaly partings, in beds varying from 8″ to 10″ in thickness. On Black Sturgeon lake some of the beds appear to be brecciated, and contain fragments of a white mineral, apparently an altered feldspar, and patches of a dark undetermined rock, probably a brown dolomite. In places there are numerous veins of crystalline calcite, and in a few cases small cavities containing calcite crystals. On the Spruce river above the gorge, and hence geologically higher than the green dolomites, is a long section through red dolomites, similar to the section above Nonwatin lake.

On Magee lake the dolomites on the south shore are dark red in colour, and are rough to the touch on freshly fractured surfaces because of the presence of minute crystals of dolomite. They are also spotted with small yellow spheroids which vary from $\frac{1}{16}''$ to about $\frac{3}{8}''$ in diameter. The beds dip to the north at an angle of 5°, and strike N. 84° W. Where they are found in contact with the trap, along the south shore of the deep bay on the west side of the lake, they become indurated and of a purplish tint, and occasionally somewhat mottled purple and red.

Northwest of Frazer lake, on the west shore of Lake Roland, some fragments of a pale yellow to green tinted dolomite, resembling the

lower beds of the green dolomites of McIntyre bay, were foun
Their area and extent is unknown.

White Dolomites.—In the valley of the Poshkokagan river the
are about 75 square miles of territory underlaid by argillaceo
dolomitic limestones. The precise boundaries are not known becau
of the extensive drift cover and the dense forest growth. In th
river bed, and on the side of the channel, there are numerous ex
posures of rock. The prevailing colour is white or yellowish whit
but some beds are mottled pale green and red. The beds have a ver
slight inclination southward. Some of them contain a number o
semi-translucent nodules which sometimes have the appearance o
fossils. The rock appears to weather easily and forms a grey-whit
clay. Dr. Hoffmann's analysis of a typical white specimen gave
calcium carbonate, 47 per cent; magnesium carbonate, 31·7 per cent
insoluble, 21 per cent, of which one-quarter was silica and three
quarters argillaceous matter.

Near the border of the area mapped the upper Poshkokagan rive
runs in a gorge nearly 140 feet in depth, the walls being more or les
talus covered. Some of the dolomitic beds are shaly, others ar
massive but weather easily. Here and there the river is under
cutting the fresh rock. The upper portion of the gorge is cut
through drift deposits, and these have obscured the higher beds o
dolomite so that the maximum thickness could not be determined
but it is probably over 100 feet. Some of the beds are quite thick
up to a maximum of about 2 feet, and the pure white, or the white
green-red mottled dolomite presents quite a handsome appearance.

Very similar dolomitic rocks are found on the south shore of
Lake Nipigon at Cooke point, just west of the outlet. Here for nearly
a mile along the shore and rising to about 20 feet above lake level
are a series of nearly horizontal beds, in which at a few places are
found small but sharply marked anticlines whose axes run nearly
north and south. The dolomites show along the base of a trap sheet
about 120 feet thick; the upper surface of the beds is a warped
surface to which the under surface of the trap sheet has conformed.

The rock is fine textured, fractures conchoidally, is thinly bedded,
and consists of alternate white and olive-green layers. Near the
contact with the trap it appears somewhat altered, being whiter and
crumbling easily. The trap also holds greenish, reddish, and dark
brown nodules and stringers, and occasionally shows veins carrying

calcite or quartz. No analyses have been made, but Coleman notes that fresh specimens show effervescence on the application of cold dilute acid, and infers that the rock is a limestone rather than a dolomite.

Several outcrops of a dolomitic limestone rock were found by Parks in the southeast quarter of the area. From his descriptions it is inferred that they are similar to the group of white dolomites described above, and for that reason they are included here.

The first of these outcrops is that of a light coloured limestone, found about a mile from the foot of Pijitawabik bay and nearly 250 feet above the lake. These rocks are thin bedded and nearly horizontal. They effervesce but feebly with acids, and average only 25 per cent of the double carbonates of lime and magnesia. The balance of the material, Parks describes as 'radio-fibrous talcose matter.' He estimated the thickness at 100 feet. He also found similar limestones about a mile and a half inland from the north end of Lake Helen. Here, at an elevation of 400 feet (presumably above Lake Helen, though not so stated), the limestone was grey in colour, semi-crystalline in texture ,and was capped by trap. It is the upper member of a series of beds the lower of which are sandstones. Eastward he found the altitude to increase to about 500 feet, and he infers that the whole thickness of the sedimentary series is at least 250 feet, implying that the dolomites are about 100 feet in thickness.

On the south side of the valley of the Jackfish river, just north of the Canadian Pacific railway, he found a similar rock overlying red dolomites and sandstones.[1]

SUMMARY AND DISCUSSION.

The Keweenawan series in the Black Sturgeon basin appears to occupy a trough-like depression between two areas of Archæan rocks — the one forming the uplifted plateau east of the Black Sturgeon river, the other forming a plateau, the whole of which lies west of the boundary of the map sheet. The order of succession, as nearly as it can be determined, and the probable thickness of the various members of the series, in ascending order is as follows: —

Basal conglomerate..	4 to 6 feet.
Grits and sandstones..	150 "
Dolomitic shales } Dolomites.. .. }	400 "

[1] Parks, 23, pp. 45-48.

It is probable that the white dolomites of the Poshkokagan are the equivalent of the red dolomites of other localities, though it may be that they are only the upper members of the series. The grey dolomites have usually been found to underlie the red, though it is by no means certain that this relation is a constant one. On the east side of the area the light coloured rocks are the highest of the series.

Parks gives the succession for the eastern portion of the area as follows: 'At the coast line of Lake Superior, immediately overlying the gneiss, are beds of rough reddish sandstone followed by red shales and marls (dolomites), rising to a height of about 100 feet. Following these are from 10 feet to 20 feet of grey sandstones, argillaceous sandstones, and argillo-arenaceous limestone, all showing evidence of rapid deposition in littoral waters. Passing northward, the red shales and marls decrease in thickness and disappear entirely at about the latitude of the middle of the township of Ledger. The grey series becomes thicker northward to a point east of the north end of Lake Helen, where it attains a maximum. From here it thins out northward and becomes less arenaceous, appearing finally near Pijitawabik bay, and on the shores of Lake Nipigon.'[1]

AGE AND CORRELATION.

This series of rocks in the Nipigon basin was first studied by Bell and McKellar in 1869. Bell classified them with Logan's Upper Copper-bearing series, but because the red sandstones resembled those of the Permian and Triassic of Nova Scotia, it was suggested that they might be of the same age.[2] In his next report he suggests the name 'Nipigon' for the series.[3] This name has been in use until recently. In the report of the Committee for the Lake Superior region the formational name of Nipigon is included under Keweenawan, the latter being classed as pre-Cambrian.[4] It is for this reason that the term Keweenawan has been employed in this report; the writer, however, is not satisfied that there is sufficient evidence available to justify the inclusion of this group of sediments in a group made up largely of pre-Cambrian rocks.

[1] Parks, 23, p. 47.
[2] Bell, 3, p. 321.
[3] Bell, 4, p. 10.
[4] Summary Report, Geological Survey of Canada, New Ser., Vol XVI, Part A., page xxvi, 1904.

No fossils have as yet been reported from the district. The area over which these rocks are found is very large, only a small fraction of the whole being included within the limits of the present map and report, and larger areal studies are necessary to enable one to reach any satisfactory conclusion. While the series has been tentatively placed in the Keweenawan in conformity with present usage, the writer does not thereby intend to imply that the rocks are pre-Cambrian in age. If the term is intended to be applied only to those rocks which are known to be older than the Potsdam, it is a mistake to extend it to include those groups the correlations of which are at present uncertain. As regards the Nipigon series, no crucial evidence has yet been adduced that definitely establishes that this series of beds is not the shoreward end of a series of sediments represented elsewhere by rocks of a similar type and classified as early Palæozoic, possibly even younger than the Potsdam. The presence of a large amount of ferric oxide from the iron ranges must have greatly altered the life conditions along this portion of the old shoreline in early Palæozoic days, and the apparent absence of fossils is not a surprising feature. Take away the red oxide of iron from all members of the series, and they would closely resemble residuals of the Black River formation found in many places along the edge of the old Palæozoic shorelines where they border the ancient crystallines. This series of rocks also differs greatly from the typical Keweenawan as developed at Keweenawan point and on Michipicoten island.

TRAP SHEETS OF THE NIPIGON BASIN[1].

DISTRIBUTION OF THE TRAPS.

Along the north shore of Lake Superior, from the Slate isl[ands] to the Pigeon river, and extending over an area reaching to [more] than 100 miles north of the Canadian Pacific railway, the m[ost] prominent geologic feature is the occurrence of large areas in wh[ich] trap sheets predominate. Within the area practically every sali[ent] feature of the topography is found to be associated with these t[rap] sheets. Along the southern edge of the district, and extending [to] about forty miles north of the Canadian Pacific Railway line, [the] traps are constantly found in association with the Keweenawan a[nd] Animikie sediments. In the northern part of the area, in the ba[sin] of Lake Nipigon, residual patches of Keweenawan sediments are f[re]quently found associated with the traps, but there are numero[us] localities where the igneous rocks of this series rest directly up[on] the older Archæan rocks.

The variegated, bold, and picturesque topography seen along t[he] line of the Canadian Pacific railway from Rossport to West Fo[rt] William, Red Rock at the mouth of the Nipigon river, McKay mou[n]tain at Fort William, Pie island, and Thunder cape, are a few of th[e] many salient features familiar to any one who has journeyed by bo[at o]r rail to Port Arthur or Fort William. The gorge of the Nipigo[n] river from north of Lake Jessie is cut through one of these immens[e] sheets, and the less well-known but more picturesque cañon whic[h] ... Fijitawabik bay, a few miles east of the Nipigon river, i[s] ... cut through the same sheet.

[Th]e sheets occur either as sills from 4 to more than 50 feet i[n] thickness intercalated with the sandstones, shales or dolomites, o[r i]n the form of capping sheets from 12 to more than 500 feet in thick[n]ess. These caps stand at the summit of the local stratigraphi[c] ... their upper surface usually is a tableland or mesa

[1] In this discussion it has been found expedient to include some des[crip]tions and data drawn from areas adjacent to that covered by this ...

Usually the trap sheets are nearly horizontal and of great extent. The largest single continuous area, so far explored, lies in the basin of Lake Nipigon, south and southwest of the lake itself. Isolated large and small outlying areas are found all around the shores of the lake, and extend north beyond the height of land.

GENERAL CHARACTER OF THE SHEETS.

The sheets, which are usually of diabase, are of two types, intrusive sills, and capping sheets. The intrusive sills are widely distributed in the region along the line of the Canadian Pacific railway, where the Keweenawan sediments reach their greatest development. Within the boundaries of the map sheet the only undoubted sill that has been noted by the writer is found at the bottom of the Spruce River gorge, about two miles west of Little Sturgeon lake. Other occurrences that may be sills have been referred to incidently when describing the distribution of the dolomites on the southwest shores of Lake Nipigon.

On Flatrock portage, between Lake Hannah and South bay, the west end of the portage road passes directly over the upper surface of such a sheet. The rock is very fine textured, basaltic in fact, and is transected by a network of fine cracks which are filled with a pink mineral, partly quartz, and partly feldspar. The net-work of cracks divides the surface into a number of (usually) pentagonal blocks, which probably represent the ends of columns. In a few places small fragments of hard sandstone or quartzite were found clinging to the surface, including one mass over a hundred square feet in area, and at least 4″ thick, thus showing that just here the diabase lay below sandstone. A few miles almost directly north of this is the Cooke Point locality, where dolomites lie beneath diabase, and this upper sheet of diabase extends southward several miles.

Some miles west of this, in the vicinity of Tchiatang bluff, blocks of sandstone are found caught up into the traps, while close at hand are the localities in which green dolomites rest on one mass of trap and are overlaid by another.

In all these cases the writer has been unable to find any conclusive evidence to enable him to decide whether there are two sheets of trap along this southern shore of Lake Nipigon or only one. Huge masses of sediments have been found with the traps above, below, and on both sides, showing conclusively in specific instances condi-

tions that might occur elsewhere. In these other localities, whe over small areas though at widely separated localities, blocks sediments have been found resting on traps, and even again overla by them, no evidence has been found to show that these beds are n merely large blocks floated off into the trap from a locality near t contact between the sediments and the underlying Archæan. will be shown in the subsequent discussion, it happens that all the areas referred to, together with the trap sheets that occur here, a closely associated with an area where an ancient ridge of crystalli rocks, flanked by sediments, was buried beneath trap sheets; fra ments of the sedimentary beds were floated off from the ridge an now stand at various angles in the trap. The latter also rests bot upon the crystalline rocks and upon undisturbed portions of th sediments as well.

The second type of trap sheet, the capping sheet, occurs nearl everywhere at the summit of the local stratigraphic column. I some cases these are undoubtedly remnants of laccolitic sills fro which the cover has been removed. As has been pointed out b Ingall,[1] many of the characteristic mesa-like ridges of this distric are due to the removal of the thin edges of these sills by erosion, an to the preservation of large masses of sediments under the thicke portion of the sill. In the greater number of cases nothing is know directly about the character of the upper surface of the trap sheet and there are reasons for believing that many of the capping sheet may have been surface flows.

In addition to diabase in the form of sheets, numerous dikes of the same rock, a few of large size, have been noted in various localities, particularly in the Nipigon basin. It has not been necessary to consider these separately from the sheets, because, so far as they have been examined, the rocks are identical. It must be noted that many of the remnants of capping sheets have been mistaken for huge dikes, and that in many instances the evidence is lacking to show whether a given mass is a dike or a sheet. As a general rule no dikes have been found in unprotected positions standing at any noticeable elevation above the surrounding rocks.

PETROGRAPHY OF THE TRAPS.

The rocks are all dark coloured, usually greenish-black or black, because of the presence of many dark silicates and magnetite.

[1] Ingall, 12.

Locally there are areas where the presence of numerous small porphyritic crystals of plagioclase give the rock a greyish tint; the green tints of surface exposures are caused by secondary chlorite or serpentine.

In texture they vary from medium to coarse; usually it is nearly uniform throughout the thickness of the whole sheet, except close to the basal and upper contacts, even when the sheets are several hundred feet in thickness. As a general rule the crystals of individual minerals rarely exceed ¼" in length; more frequently they are smaller. Close to the contacts with the earlier rocks the diabase usually becomes very fine textured and of a general basaltic appearance. Occasionally the texture may locally become very coarse; porphyritic olivine crystals over an inch across were found in a small remnant of diabase south of the portage leading east from Sucker lake, in the Windigokan region. Large poikilitic augite crystals are found in many places, and in weathering they cause the formation of a characteristic gravel of nearly spherical pebbles ¾" in diameter, or smaller.

Diabase is by far the most abundant rock; olivine diabase is frequently found in large areas, and it seems probable that these are but two of the many phases of the same rock. Structurally it may pass from a typical diabase, the prevailing rock, to a coarse gabbro, or locally to a fine-grained porphyrite. The rocks are invariably holocrystalline and never amygdaloidal.

All the traps contain a light brown augite in considerable amount, and a plagioclase not very rich in lime, and all contain magnetite, but in varying amount, and usually a little pyrite. In almost all cases the rocks exhibit the typical ophitic structure of diabase, the automorphic feldspars often being completely included within the augite or magnetite. Biotite, frequently more or less altered to chlorite, is present in all specimens. Many of the diabases contain olivine, usually more or less altered to serpentine. Among the olivine diabases several specimens were found which contain in addition to the normal brown augite, a peculiar brownish augite that, between crossed nicols, exhibits a texture comparable to the micropegmatitic intergrowth of quartz and feldspar. In this case the structure is due to an intergrowth of augite and a rhombic pyroxene. The latter is intergrown parallel to the prismatic faces of the augite, each mineral extinguishing by itself when rotated in polarized light. It is interesting to note that when the magma was

sufficiently rich in magnesia to give rise to olivine, it at the
time gave rise to this intergrowth of the two pyroxenes. This m
perthitic augite, associated with normal brown augite and oli
was found in specimens of diabase from the lower, and prob
older, sheet at Long Point bay on Black Sturgeon lake, and
Splitrock portage. All specimens examined from the inte
plateau south of Lake Nipigon and east of Black Sturgeon lake
olivine free diabases, and contain only the normal brown augi

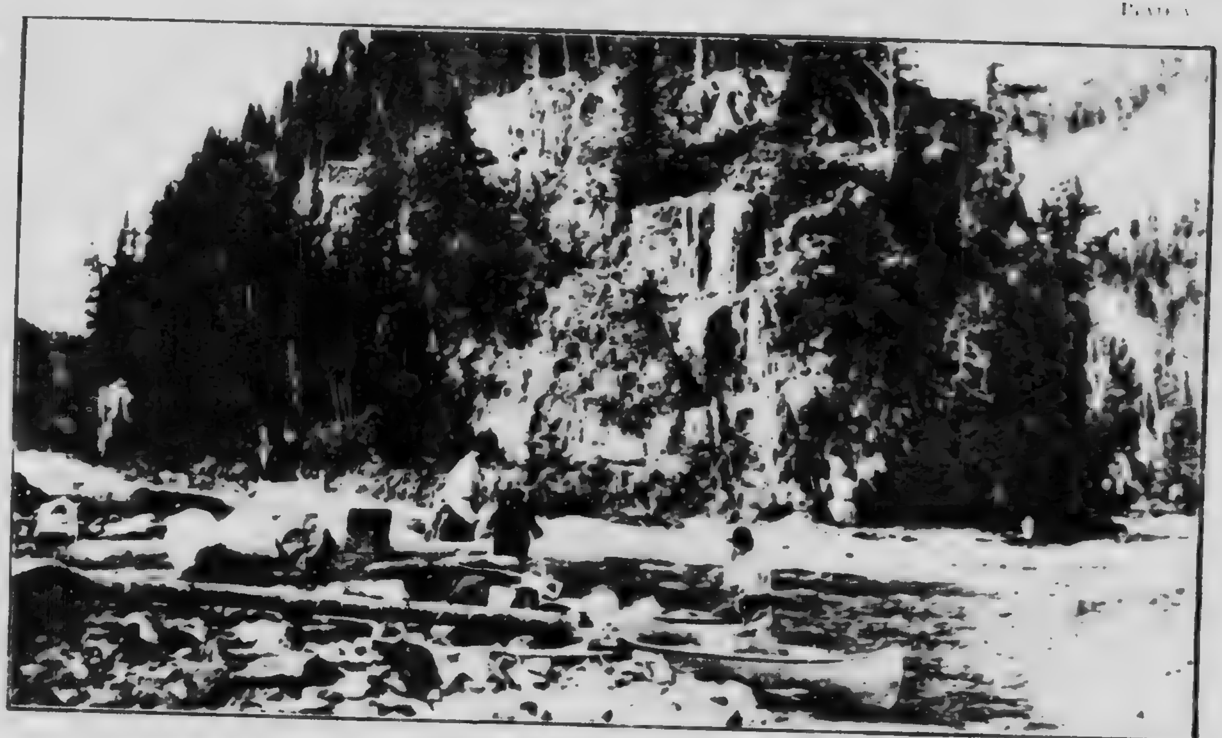
STRUCTURE AND WEATHERING OF THE DIABASE.

The development of three or more systems of joint planes, sumably consequent on the shrinkage of the igneous rock w cooling, has rendered the rock particularly subject to attack f erosive agents. Two of the three systems of joint fractures vertical, or nearly so, and intersect each other at an angle gener somewhat greater than a right angle. The third system is so times horizontal, but more frequently it is inclined, sometimes e at a high angle. Where the vertical jointing system is well veloped, cliff fronts often possess a columnar structure. When third system of jointing is well developed the edges of the trap she often simulate bedded sedimentary rocks, or sections of the c front may resemble an ancient wall, particularly when the horizon joints are somewhat closer spaced than the vertical ones, and rocks are weathered slightly along the joint planes.

Occasionally there are areas where the jointing is spheroi rather than rhombohedral, but these are usually small and the ma jointing even in these areas is rhombohedral. In the vicinity of t small anticlinal arches developed in the underlying dolomites Cooke point, the jointing in the diabase immediately above the arch has been so modified that the relative arrangement of the bloc suggests an artificial arch over the anticline. One set of join corresponding to one of the vertical systems of joints in the san sheet at some distance from the arches, has become radial from th axis of the arch, while the horizontal joint system is represented b a curved system of joints approximately concentric with the curve of the arches of the anticlines.

Erosion processes, and more particularly frost action, displac these joint blocks, even those of very large size. Many of the tra sheets are also underlain by soft and easily eroded rocks. As a con

Plate [illegible]



Island at the Spirit Rock [illegible] Nipigon [illegible]

[illegible]

6618-p. 76

sequence the edges of the trap sheets present steep inaccessible cliffs with a pseudo-columnar structure, and an immense [illegible] angular blocks at the base.

On the uplands where there is no vegetation the surface is often covered with fragments of more or less spherical shells or plates of diabase, chipped off through the alternate expansion and contraction, brought about by the contrast between the day and night temperatures.

Where the rocks are kept moist by a moss cover, chemical solution plays an important part in their disintegration, and old glaciated surfaces are usually found to have become roughened and corrugated. In the later stages of weathering the rocks break down into a rusty gravel. In many places the presence of the poikilitic augite crystals gives rise to a peculiar brownish gravel consisting of nearly spherical pebbles of various sizes, but rarely more than 1" in diameter.

ORIGIN OF THE TRAP SHEETS.

Earlier Views.—The earlier students of the district regarded these diabase sheets, in whole or in part, as volcanic flows, the lower and thinner sheets being considered as contemporaneous with the sedimentary rocks with which they are associated, while the capping sheet was designated the 'Crowning overflow' by Sir William Logan.

Later Views.—Later work by Ingall[1] and Lawson[2] has combatted these ideas, and the view so admirably set forth by Lawson has come to be generally accepted. Lawson's thesis is:—

'There are no contemporaneous volcanic rocks in the Animikie.'

'None of the trap sheets associated with the Animikie, whether of the nature of "caps" or interrealated sheets, is a volcanic flow.'

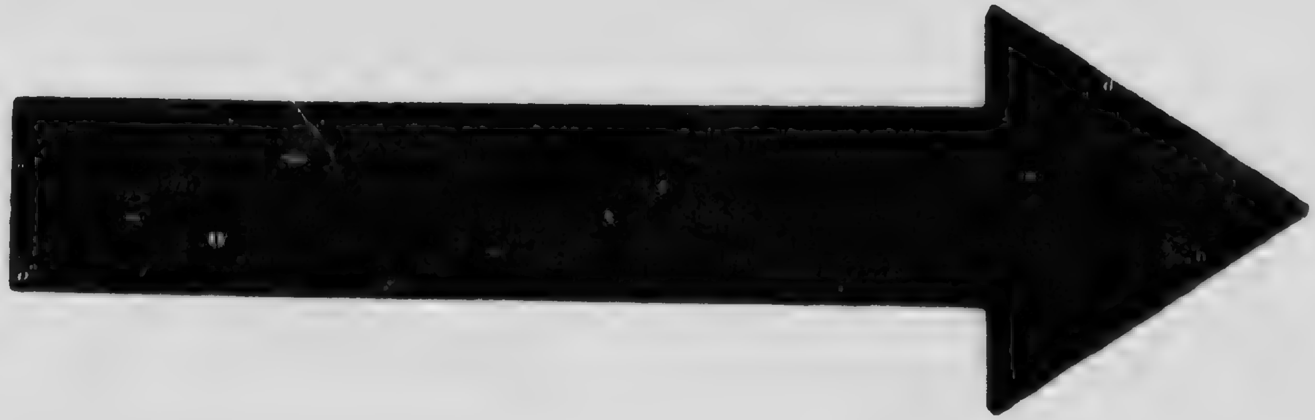
'These trap sheets are all intrusive in their origin, and are of the nature of laccolitic sills.'

Lawson further summarizes the data on which he founds these theses in the following statement (p. 44):

'I. The trap sheets associated with the Animikie strata are not volcanic flows, because of the combination of the following facts:—

'(1) They are simple geologic units, not a series of overlapping sheets.

[1] Ingall, 12, pp. 42, 46, 79, 80, 99.
[2] Lawson, 13, p. 29.



MICROCOPY RESOLUTION TEST CHART

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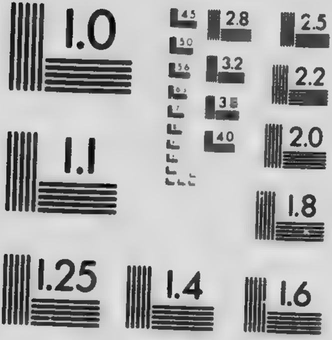

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'(2) They are flat with uniform thickness over more than 100 square miles in extent, and where inclined, the dip is due essentially to faulting and tilting.

'(3) There are no pyroclastic rocks associated with them.

'(4) They are never glassy.

'(5) They are never amygdaloidal.

'(6) They exhibit no flow structure.

'(7) They have no ropy or wrinkled surface.

'(8) They have no lava breccia associated with them.

'(9) They came in contact with the slates after the latter were hard and brittle and had acquired their cleavage: yet they never repose upon a surface which has been exposed to subaerial weathering.

'II. They are intrusive sills because of the combination of the following facts:—

'(1) They are strictly analogous to the great dikes of the region. (*a*) In their general relations to the adjacent rocks, and in their field aspect. (*b*) In that both the upper and lower sides of the sheets have the facies of a dense aphanitic rock, which grades towards the middle into a coarsely crystalline rock.

'(2) They have practically a uniform thickness over large areas.

'(3) The columnar structure extends from the lower surface to the upper surface, as it does from wall to wall in dikes.

'(4) They intersected strata above and below them after the latter had been hard and brittle.

'(5) They may be observed in direct continuity with dikes.

'(6) They pass from one horizon to another.

'(7) The bottom of the sedimentary strata above them, wherever it is observable, is a freshly ruptured surface.

'(8) Apophyses of the trap pass from the main sheet into cracks of the slate above and below.

'(9) The trap sheets, particularly at the upper contact, hold included fragments of the overlying slates.

'(10) They locally alter the slates above and below them.'

For purposes of discussion the diabase sheets may be divided into two great groups: that group of sheets where both the upper and the lower surfaces are known, or where their character can be readily

inferred, and a group consisting of all those sheets whose under surface only is known—the group which forms the various topographic 'caps' throughout the whole region.

With reference to the first group, the observations of the writer conducted over a wider area, emphatically confirm Lawson's conclusions as outlined above. With reference to the capping sheets, the writer's observations are in accord with Lawson so far as the areas examined by both are concerned, but data obtained largely in the basin of Lake Nipigon, lead him to make a somewhat different interpretation of facts recorded by Lawson and by himself, and to different conclusions.

Scope of the Discussion in this Report.—The writer wishes to confine the present discussion wholly to the consideration of the nature of the relations which now exist, and possibly formerly existed, between that group of sheets of diabase which now form the 'caps' and the underlying rocks. So far as all other masses of diabase within the area are concerned, his observations confirm in every respect those of Lawson. Hence that there is a group of diabase sheets in this region which are not volcanic flows, but which are intrusive sills of a laccolitic type, is considered to have been established, and is not a subject of discussion in this report.

Character of the Flows—accepted Data and Conclusions.—With reference to the 'caps,' it must be recognized at the outset that only contact surfaces at the bases of the sheets can be studied. The character of the upper surfaces and the nature of the contacts, if any, can be a matter of inference only. Possibly a few of the 'caps' belong to the first great group of sheets in which the character of the upper surface can be directly inferred from evidence available. The greater number of caps exhibit no direct evidence as to the character of their upper surface, and it is with these that the present discussion deals.

Negatively they exhibit none of those characteristics which are usually associated with volcanic flows—there are no pyroclastics, they are never either glassy or amygdaloidal, never exhibit ropy or wrinkled surfaces, have no associated lava breccias, and the nature of the contact with the underlying rocks shows that the latter were hard and brittle before the traps came into the area. So far as negative evidence is concerned, they exhibit none of those features which are usually considered as characteristic of volcanic flows.

DESCRIPTIONS OF CRITICAL AREAS.

The nature of the basal contacts of these sheets, and the general character of the sheets, can be best understood from the study of a selected few from a very much larger number of concrete examples. The examples which are cited in the succeeding paragraphs are only a few typical instances in which the relations of the traps to the adjacent rocks are clearly depicted. They have been selected because they are in localities readily accessible, and because they are all, with the exception of Red Rock, within the Nipigon basin, and are directly associated with the principal area of diabase.

Gorge of the Nipigon River.—At Island portage on the Nipigon river, about five miles above Lake Jessie and in the heart of the gorge, Archæan gneisses are exposed in the channel of the river. On the east side there is a high cliff of gneiss rising about 350 feet above the river, which has usually been mistaken for diabase, as it is nearly continuous with the diabase cliffs which swing in from the east at Lake Jessie and continue up this side of the gorge almost to Lake Nipigon. On the west side of the river at Island portage is a coarse pegmatitic granite rising about 250 feet above the water.

The area of Archæan exposed in the gorge and on the adjacent uplands, completely surrounded and partly capped by diabase, is about four square miles. At Lake Jessie the diabase is found nearly 300 feet lower than the top of the gneiss dome, with possibly not more than 100 feet of sediments between it and the underlying Archæan. The south edge of this sheet has been traced from a point nearly thirty miles east of the Nipigon, and for twelve miles west. The base usually rests on sediments throughout this distance of over forty miles, the sediments in turn resting on the very uneven surface of the Archæan rocks.

The position and attitude of the Archæan island in the diabase near Island portage suggest a pre-sedimentary monadnock, partly denuded before the advent of the diabase, buried by it, and subsequently uncovered by various erosion processes, the latest event in the geological history being the formation of the Nipigon gorge.

Tchiatang Bluff.—At the southwest corner of Lake Nipigon is a deep bay lying between diabase headlands, called Grand bay. An inner bay at the bottom of Grand bay, on the route leading south to Black Sturgeon lake, is called Black Sturgeon bay. The south

PLATE VI

Columnar diabase cliffs on the lower part of Pijitawabik bay, Lake Nipigon

PLATE VII

Diabase pinnacle near the south end of Herrick lake.

shore of this latter bay is bounded by a high bluff, the relief being over 700 feet. In the narrows between Kelvin bay and Black Sturgeon bay, a little more than half a mile from the base of the bluff, is a small island known as Gneiss island, the bed-rock exposed being gneiss. Between this island and the bluff, soundings gave a depth of 66 feet. The entire bluff, to the summit, is diabase, and the highest part lies back from the cliffed front of the bluff (325 feet) about half a mile, and stands about 650 feet above the lake. At three points on the face of this bluff masses of sandstone, now almost quartzite, are found in the diabase. At least one of these is about 25 feet in thickness and stands nearly vertical. About two and a half miles west of Gneiss island, at the foot of the bluff, another mass of gneiss outcrops, rising at least 150 feet above the lake, and is capped by the same trap sheet. Four miles south of this is a ridge of granite-gneiss which can be traced in a southeast direction, with varied expression, at times partly covered with either sediments or diabase, or by both, for a distance of twenty miles, where it joins the large area of Archæan rocks lying east of Black Sturgeon river. The two small exposures of gneiss seen at Tchiatang bluff are topographically at a lower level than the main area to the south, and the second one noted probably represents the tip of the north end of a long ridge of Archæan rocks.

Following the face of the bluff south to the narrows leading to the portage on the way to Black Sturgeon lake, there is a large mass of sandstone in the diabase just east of the narrows. This sandstone has a dip of about 80°, and is probably an inclusion in the latter.

Four miles south of the bluff, and about one mile east of Black Sturgeon lake, there is a large area of sediments resting directly upon the Archæan, the actual contact with the lower basal beds being exposed. About two miles inland the diabase overlies these beds. It is not known whether there are any sheets of diabase intrusive in these beds. East of the south end of Black Sturgeon lake the same sheet of diabase rests directly upon Keewatin rocks.

Hence, in the vicinity of Black Sturgeon bay and Black Sturgeon lake, we find the upper diabase sheet resting directly upon Archæan gneisses and granites, Keewatin schists, and Keweenawan sandstones and dolomites, (at Magee lake) five different types of rocks belonging to three formations, and in addition there are some inclusions of sandstones in the diabase, standing in various attitudes from nearly horizontal to almost vertical.

Spruce River Gorge.—The main stream running southeast fr Black Sturgeon river is the river of the same name. Through mo of its course from the lake to Black bay on Lake Superior it flo along a lowland bounded on the southwest by a cuesta formed Keweenawan sandstones and dolomites, the strata having a sout westerly dip. On the northeast side of the lowland is an extensi

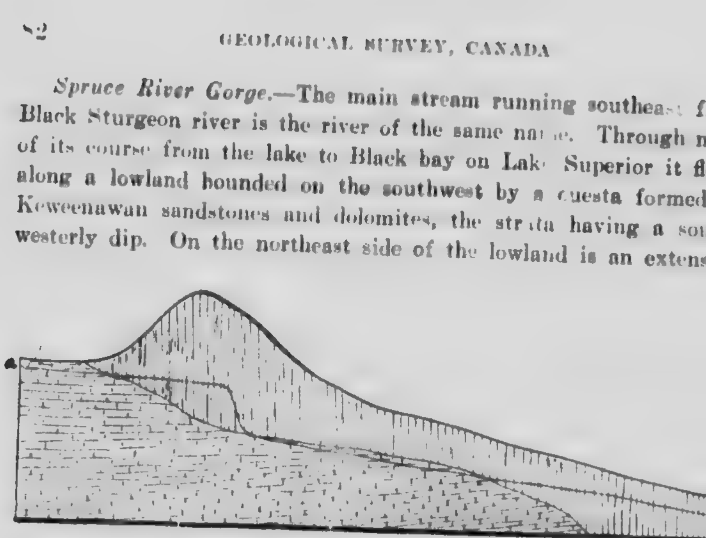

FIG. 2.—Section on Spruce river, 10 miles southwest of Black Sturgeon lake. The profile of the stream bed is shown at *a*.

area of Archæan oldland. The cuesta rises about 300 feet or mor above the river, and in places it is capped by remnants of diabase sheets. At one point in the river bed there is also an outcrop of diabase, but the relations of this isolated mass to the surrounding rocks are unknown. The escarpment which forms the edge of the cuesta can be traced from just above the Canadian Pacific Railway bridge to a point some fifteen miles west of the south end of Lake Nipigon, where it terminates. Outlying remnants of the sediments are known in several localities still farther northwest.

About ten miles southwest of Black Sturgeon lake, the Spruce river, an important tributary, flows down the face of the escarpment through a gorge cut in diabase, and eventually it reaches Black Sturgeon lake. Above the gorge the river flows in a channel cut in red Ke[illegible] dolomites. On approaching the edge of the escarpment i[illegible] [illegible]teway formed by the edges of one of the diabase sheets, [illegible] rises fully 350 feet above the upper surface of the sedime[illegible] [illegible]n the upper part of the channel is carved. The stream in [illegible]ng through the gorge cascades and falls over diabase. Near the foot of the principal falls, about 90 feet below the level of the river above the gorge, greenish dolomites are exposed in the bottom of the channel, and the sides are bordered by diabase. Down stream about two miles from the head of the gorge, and probably

about 170 feet below it, no further sediments are encountered, and the stream channel is located on diabase. Numerous exposures of diabase between this point and Black Sturgeon lake make it seem probable that below the escarpment the whole area in the foreground is immediately underlain by diabase, this resting in turn on sediments. Not far from the place where the river enters Black Sturgeon lake sediments are again encountered. There can be no question but that in this locality a diabase sheet at least 300 feet in thickness lies along the edge of the cuesta, descends its front, and overlies a very large portion of the lowland in the immediate foreground, and probably as far east as Black Sturgeon lake.

Nipigon House Outliers.—Just north of Nipigon House, on the side of a hill of granite porphyry, and covering an area of less than half a square mile, is a small detached mass of diabase lying in a local hollow, the main part of the hill rising behind it. In other hollows on the same ridge are two small patches of basal sandstones and a second area of diabase. On the west end of Jackfish island, less than half a mile away, diabase is found at water level in immediate contact with the same granite porphyry.

About six miles north of Nipigon House, on the Inner Barn island in Wabinosh bay, the remnant of the same diabase sheet has a thickness of about 600 feet, and probably overlies a few feet of basal sandstones. On the mainland south of the island other contacts between the diabase and the underlying granite are found, and some boulders of granite were also found in the diabase near the bottom of the sheet.

Wabinosh Valley.—About eight miles northwest of Nipigon House the Wabinosh river enters Wabinosh bay on Lake Nipigon. Ascending the Wabinosh river towards the northwest, at Waweig lake, about eight miles up-stream, granites and gneisses are exposed near the shores of the lake and at a number of points in the bottom of the valley in which the river runs for the next twelve miles of its course. On either side diabase bluffs rise to an elevation, in round numbers, of 300 feet above the valley. Ascending these bluffs on the north side of the river valley, and descending on the other side, at a distance varying from one to two miles from the river, and at a height of between 145 and 160 feet above it, the granite gneiss is again encountered. The north edge of the diabase sheet is thus shown to abut against the side of an ancient valley in the Archæan,

and the depth of this valley was at least 150 feet. The preserved portion of the diabase sheet between the valley of the Wabinosh and the Archæan highlands to the northeast of it now lies on the side of this old Archæan valley.

Ombabika Narrows.—At the northeast angle of Lake Nipigon is found one of the most interesting contacts of the district. The remnants of the diabase sheet have, in the vicinity of Ombabika narrows, a thickness of about 400 feet. On the north side of the narrows, just opposite the small island which divides the channel into two parts, the diabase flowed over rocks which had previously been eroded in such a way as to produce an undulating surface (or a warped surface). Subsequent erosion and glaciation have removed almost all of the diabase. Because of the position of the high ridges of diabase on either side of the narrows, and because of the relations which the fronts of these cliffs bore to the direction from which the movement of the ice sheet took place, erosion was especially active at this point, and the present surface, also a warped surface, is remarkably smooth. It has happened that over an area of several hundred square feet, glaciation stopped at such a point that the present surface intersects the old pre-diabase warped surface in such a way that small areas of trap now occupy small hollows in the old surface, and in a low cliff sections of contacts in both vertical and horizontal planes are exposed.

At the west end of the island in the narrows there are a large number of large and small granite boulders, derived from the immediately underlying Archæan rocks, included in the diabase, with their upper surfaces planed off by the glaciation.

Within two miles of the narrows, towards the south, there are at two points very small exposures of white quartzite with the diabase overlying, actual contacts being observed. Along the shore for eight miles south of the narrows there is a narrow but nearly continuous strip of granite-gneiss exposed along the shore, the diabase rising in a ridge behind it.

On the northwest side of Humboldt bay, eight miles southeast of the narrows and across the ridge of diabase which forms the main axis of the south peninsula of Ombabika, there are several areas both of granite-gneisses and Keewatin schists overlain by traps, actual contacts being seen.

On the east side of the north arm of Humboldt bay, about two miles from the contact between Keewatin schists and the diabase,

the remnant of the trap sheet rests on Keweenawan sandstones; these in turn rest on granite. This area of sandstone is an isolated patch, with a minimum thickness of 50 feet Since the diabase is found in actual contact, not only with the sandstones, but also with the underlying rocks, the contact is an unconformable one.

Possible Remnants of Old Soils in situ.—Within the Nipigon basin the greater number of contacts noted between the base of the remnants of the capping sheet of diabase and the underlying rocks were in areas where the Keweenawan sediments had largely been removed prior to the volcanic extrusion. In some four places, two of which have been mentioned above, boulders of Archæan rocks have been found within the diabase close to the basal conta[illegible]. [illegible]ontacts between Keweenawan sediments and the igneous rock are also frequently found, but the best examples lie to the south of the Nipigon basin, along the line of the Canadian Pacific railway, in the district that is underlaid chiefly by these sediments, and the area in which the intrusive sills are so abundant.

Near the mouth of the Nipigon river, three miles southwest from Nipigon station, the railway track skirts the foot of a diabase-capped bluff known as Red Rock (from the characteristic colour of the underlying sediments). At this locality (mile post 66 from Schreiber) the diabase sheet ascends across the beds, to a height of about 140 feet, and the upper part of the sheet seems to rest practically conformably upon the upper beds. Where the diabase crosses the truncated edges of the lower beds (to be seen close to the railway track) between the base of the sheet and the undisturbed portion of the beds, is a mass of broken rock at least 10 feet in thickness at one point, and probably thicker elsewhere. This breccia consists of small fragments of the sediments, many of them partly rounded, and the whole now recemented and bleached to a colou[illegible] lighter than that of the parent beds. The recemented beds seem [illegible] have [illegible] slight downward dip towards the ascending trap sheet

At mile post 67, on the opposite side of the same ridge, are more exposures of a similar breccia, not in imm[illegible] contact with the diabase sheet. Nearly midway between th[illegible] [illegible]nts one of the railway cuttings passes through a dome [illegible] [illegible]nts in which many of the thin shaly beds are crumpled [illegible] heavier beds are folded or faulted locally. While there ar[illegible] [illegible]xposures of diabase in the exposed portion of the core of the [illegible]me, its form and

structure strongly suggest that the strata are arched up by a l colitic mass from below.

Lawson cites the local unconformity between the diabase and t sediments as an example of the intrusion of a laccolitic mass of t diabase across the beds. We have, however, no information as to t actual character of the upper portion of the capping she and the absence of this positive information, the writer would, on th basis of other collateral evidence, interpret the section differently.

At first sight the apparent downward dipping of the edges of th beds at the contact with the diabase suggests mo linal faultin Directly opposite, across the river, similar sediments also capped un conformably by trap, form a similar bluff standing at almost pre cisely the same level, the distance between the two bluffs being les than a mile. If there were monoclinal faulting, accompanied by th intrusion of the diabase along a pl in the fault zone, not only would the occurrence of escarpments of nearly equal height on opposite sides of the fault plane be improbable, but the lifted block

FIG. 3.—Section at Red Rock at the mouth of the Nipigon river. Intersection of Keweenawan strata by diabase, showing a small mass of supposed old soil breccia at the base of a pre-diabase cliff. One hundred and forty (140) feet of sediment are capped by 125 feet of diabase.

would be the block *above* the trap sheet, not the one *below*, and in this case both blocks are *below* trap sheets. Again, if the molten diabase had been forced upward from below along the fracture plane, it seems probable that if it disturbed the edges of the strata through which it passed, it would tend to bend them *upward* in the direction of flow, rather than downward. Where the diabase was in a very fluid condition, as presumably it was in this case from the nature of the crystalline structure of the solidified magma, where fracturing was produced along the line of intrusion, small fragments would almost certainly have been washed out into the diabase, and the latter would have insinuated itself between other fragments nearer the parent beds; but in no case were phenomena of this character

noted. The fragments are fairly uniform in size, no very large blocks being noted, and are frequently rounded at the corners and edges. The whole mass is recemented with a material that was probably derived from the beds themselves.

The block of sediments now exposed in section above water level very strikingly resembles such a ridge as could be duplicated many times among similar sediments, a flat-topped ridge fronted by a nearly bare sandstone cliff, with a small talus at the base. The apparent downward drag of the beds at the contact between the breccia and the diabase is precisely similar to the soil drag found on steep faces of escarpments or slopes where the edges of thin beds containing shale members are exposed.

The writer is thus inclined to regard the breccias, found only along the base of the hill, as old soil breccias, and the unconformity at this point as evidence of extensive erosion previous to the incursion of the trap.

An almost precisely similar breccia, in which many of the fragments are distinctly rounded, occurs near the post-office about one and a half miles east of Ouimet station (between M. 87 and M. 88), where it is also associated with, but only partially concealed by, a trap sheet—both at the foot of a slope and at its summit.

Again, at mileage 97¾ is a mass of very similar material consisting of fragments of red arenaceous dolomites lying in a hollow in granite, and not now associated with any trap sheet.

The breccia found at the base of Red Rock, on the east side of the ridge, is in immediate contact with the diabase, and is only a small fragment of material similar to that found in several other localities, not always associated with diabase at the present time, and not necessarily occurring at points where an intrusive mass has forced its way across strata. Under any other circumstances these fragments of waste rocks would unhesitatingly be regarded as remnants of an old soil cover. Except for the fact that they are recemented, they are almost precisely similar to the waste masses found in many other places associated with these same rocks to-day.

DISCUSSION OF THE EVIDENCE.

Surface Flows versus Intrusions.—Obviously the capping sheets of diabase, the group under consideration here, must have been either surface flows or intrusions. Were the original upper surface of the sheets preserved it is extremely probable that there would be no

difficulty in determining to which group they belonged. If they w surface flows we would expect to find the upper layers glas amygdaloidal, with traces of flow structure, occasionally perh associated with lava breccias or other pyroclastics. If intrusions could expect to find traces of the overlying sediments, or, interna at or close to the former upper contact the diabase would conta fragments of the old cover at times, and would always show a p gressive diminution in the size of the grains of the constitue minerals as the contact was approached, precisely the same as shown in all cases where both upper and lower contacts are know Unfortunately it happens that all traces of the actual character the upper portion of these sheets have been lost. In the Lake Nipig basin alone there can be no question but that more than 80 per ce of the original volume of the mass of diabase that once was prese has been removed, assuming that it had even a minimum thicknes of between 600 and 700 feet (600 feet being the actual thickness o the remnants of the sheet in several places). When it is remembere that at the very summit of the thickest sheets known we find n change in texture indicating that an upper limit is being approached it seems conclusive that before erosion began the sheets were ver much thicker than their thickest remnants are to-day. While i would be rash to give any figure as a possible maximum based on the data now available, still if a minimum of 1,000 feet is allowed it will be found that more than 90 per cent of the volume of the original sheets has been removed from the area of nearly 6,000 square miles here under discussion.

In view of the enormous amount of erosion that undoubtedly has taken place, whatever may be the accuracy or inaccuracy of the approximations given above, and in view of the fact that no record has been preserved as to the actual character of the upper part of the upper sheets, even if they were intrusive, the non-appearance of any phenomena that can be associated with a volcanic flow must be regarded as a negative argument of very slight weight, and in this instance an argument of equal weight for both types of invasion, since each type has a characteristic upper surface under normal conditions. In fact the preservation of the upper layers that were more or less glassy and porous, the characteristic features of most surface flows, would be extraordinary in a locality where the erosion has been so extensive, for such a surface would be even more susceptible

to the action of erosive agents than either sediments or the upper surface of an intruded sheet.

It must also be considered that the features characteristic of the upper portion of a flow are confined to a few feet of the upper parts of the sheet. If there were a number of successive flows, following one another at intervals, so that the upper surface of the earlier one had had time to cool before the next flow came upon it, it is very probable that remnants of these surfaces would have been preserved.

A comparable instance is that of the Columbia lava fields, which cover an area of 200,000 square miles. The lava fields are built up by a number of separate flows, and the thickness varies from between 300 and 400 feet along the edge of the cañon of the Columbia river to 3,700 feet, according to LeConte, in the Cascade mountains near Dalles.[1]

Russell describes the rock as usually a compact bluish-black basalt, with frequently a well-defined columnar structure—'but also at times it is vesicular and scoriaceous, especially on the surface of sheets.'[2]

If, in the Lake Nipigon area, the lavas were very fluid, and if the flows followed one another closely so that the earlier flows had not had time to solidify before the later followed upon them, or if there were only one large flow, the fluid lava would tend to accumulate in the basins and hollows of the invaded district, would heat the underlying rocks, possibly even refusing parts of the lava that had cooled on the first contact with the cold underlying beds on which it rested, and would remain fluid for a very long time—giving ample opportunity for the development of the crystalline texture so characteristic of the basal portion of the remnants of the sheets.

In this event the characteristic upper surface would be confined to the highest members only, and below a certain limiting depth the cooling of the mass would proceed as if it were a laccolitic mass below a sedimentary cover. For this reason also no argument can be based on variations in the texture of the crystalline rock. While the marked uniformity of the grain of the rock, except close to the base of the sheets, suggests slow cooling, nearly simultaneous solidification throughout the greater portion of the sheet, and the existence of a cover, it offers no evidence as to the character of that cover.

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[1] American Journal of Science, Series III, Vol. 7, 1874, p. 168.

[2] Russell, I. C. A geological reconnaissance in Central Washington, United States Geological Survey, Bulletin 108, p. 21.

Unconformities.—The occurrence of numerous unconformities i an established fact. Broadly they are of three types:—

The diabase sheet appears to truncate the edges of nearly horizon tal beds of sedimentary rocks, in place, resting upon Archæan rocks

The diabase rests on an eroded and uneven surface which trun cates the structures of metamorphic rocks;

The diabase rests on an uneven surface which truncates both Archæan metamorphics and overlying later sediments—rocks of two or more formations.

Examples of each type.—Contacts of the first type are particularly numerous along the line of the Canadian Pacific railway. Reference has been made to the unconformity at Red Rock. A number of other examples are described by Lawson, more particularly, however, with respect to contacts between the diabase and the underlying Animikie rocks. The unconformity in the gorge of the Spruce river also belongs to this group.

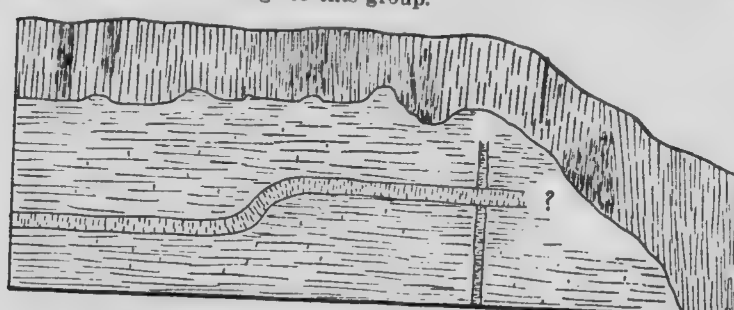


FIG. 4.—Diagrammatic section near the extremity of the point between Big Trout and Pigeon bays. Showing the relation of the trap sills to the Animikie strata. (After Lawson).

The explanations offered by Lawson and Ingall on the one hand, and by the writer on the other, so far as they apply to these major unconformities, are diametrically opposite. In so far as these unconformities alone are concerned the writer's verdict would be 'not proven,' but when the various other unconformities are also considered, the balance of evidence seems to be strongly in favour of the later explanation.

Contacts of the second class are numerous all around Lake Nipigon. One of the most striking of these, at Ombabika narrows, has been described in some detail, and attention has been called to the inclusion of boulders of the underlying rocks in the diabase. Another example from near Nipigon House has also been cited, and

the occurrence of included boulders noted. There are also a number of other localities where masses of diabase, covering areas varying from about one acre to over ten square miles, show actual contacts with an eroded crystalline surface, and in some instances they contain detached blocks of Archæan rocks similar to the bed-rock on which they rest. The diabase masses occur on the tops of ridges and on the sides of valleys cut in the Archæan (as at Wabinosh river, Nipigon House, Tchiatang bluff), as well as in the bottoms of such valleys. Archæan valleys with a minimum relief of 150 feet are found to have masses of diabase located on their sides, and it is probable that these preserved remnants are retained in these partly protected spots because of a finer and more compact texture than must have characterized the portions of the same sheet further removed from the valley floor on which the sheet rested.

The contacts of some of the smaller remnants of the diabase sheets and the underlying rock show in detail the nature of the surface over which the molten rock flowed, and show that it was very intricate. There are many instances in which it can be shown that what appear to a traveller in the valleys to be high ridges of diabase, rising above the adjacent depression, are merely the edges of a dissected sheet of trap, the present remnants now lying on the sides of old valleys cut in the Archæan rocks. Since the diabase is harder and more compact near contacts with other rocks, a reasonable explanation of the occurrence of this type of ridge is that the remnant of diabase is preserved where it lies because of its relation to the underlying rock, and because of the texture thereby developed in this part of the sheet in the process of cooling. The high cliffs at Tchiatang bluff, where there is a relief of over 700 feet, and diabase for at least 650 feet of this height, may be a case in point. The whole core of the bluff may possibly be Archæan, and the diabase only occur as a sort of plaster over its face. There is no reason to suspect that all the apparently thick sheets are of this type; in the case of the Inner Barn island, for example, the thickness is about 600 feet, and one may go completely around the sheet.

The third type of unconformable contact has been illustrated by the description of the vicinity of Island portage on the Nipigon river. Other examples cited are Tchiatang bluff and Humboldt bay, the latter being mentioned when describing the Ombabika Narrows locality. About ten contacts of this type have been examined by the writer, well distributed over different parts of the area, and it has

been definitely established that the unconformity they indicate is n confined to any specific locality.

Discussion.—As has already been pointed out, the first type unconformity has been explained either by the theory of a flow ov an eroded surface, or by assuming that the diabase was intrud across the beds. In the latter event it appears to the writer th certain evidence of this intrusion would be found at the contacts the relationships which would then exist between the intruding ro and the edges of the fractured strata. This direct evidence is lac ing, and so far as the first type of unconformity is concerned, concl sive evidence has not been cited.

The second and the third types of unconformity have not, so fa as the writer is aware, been previously discussed in print; thoug Bell, in 1869, noted that there was an unconformity, he does no appear to have appreciated either its significance or its real extent There are but two possible ways in which it could have been brough about. The diabase must have flowed over an eroded surface, or i must have forced its way into its present position along the surfac of contact between an overlying cover and the rocks with which i is in contact.

Naturally, surfaces of contact between the sedimentary rocks and the underlying Archæan would be supposed to have been the locus of a number of lines of least resistance (or a plane of least resistance). Had the Archæan surface been only moderately even it is possible that it would have lain in the plane of least resistance. But the surface is an undulating one with a moderate relief of at least 300 feet, and in places more than this. In detail some parts of the surface are extremely intricate, yet we find numerous instances in which the diabase occupies not only major depressions in the surface, but has even insinuated itself into minor irregularities. It has done this not in a few localities, but in many places widely distributed. Had it insinuated itself between an overlying cover and the rock on which it now rests, normally one would expect to find numerous small remnants of the sediments in the bottoms of the major hollows at least, rather than to find so complete a stripping as seems to have taken place. In the second place, the edges of the sheets, with the sediments underlying, have been followed and examined for many miles and by many observers, and no single instance has been recorded where n intruded diabase sheet has followed the sinuosities of the

contact surface between the sediments and the underlying Archæan. In other words, while in the whole area numerous sheets have been intruded into the sediments in addition to the sheets that now form the 'caps,' yet in no single instance has one been found to have intruded itself along the supposed plane of weakness at the contact between the sediments and the underlying rocks.

In the case of unconformities of the third type, under the intrusive theory the diabase must have occasionally been unable to insinuate itself along the intricate surface of the Archæan, and must have broken across the beds of the sediments to a higher horizon, leaving a remnant firmly attached to the original basement, and again descending after the obstructing mass was passed—an improbability not only because of the physical difficulties involved, but also because at the contacts, so far as recorded or examined, no evidence of violent disruption or intrusion has been found.

Again, numerous contacts between the sediments and the Archæan show that usually the basal beds are arkoses or conglomerates, and contain at least a few pebbles, cobbles, or boulders derived from the underlying rock. In four widely separated localities, yet each in the vicinity of unconformable contacts between the diabase and two other formations, boulders of the underlying Archæan have been found in the diabase, at or close to the contact. The diabase in actual contact with these boulders is fine textured, but it is not glassy, and the zone of alteration, even in the immediate vicinity of one boulder about 5 feet across, is very narrow—from which one can infer that the boulder lay in the fluid or semi-fluid diabase long enough to become heated through, and that it had but little effect on the cooling of the diabase magma in its immediate vicinity.

No fragments of any sandstone or other cement material, similar to that found in the basal conglomerate, were found either in the diabase or clinging to the boulders, so far as seen.

It seems very improbable that the several masses of diabase in which these boulders now lie were intruded between the basal beds, similar to those in adjacent masses of sediments, and the Archæan rock on which the trap containing these boulders now rests.

Columnar Structure.—Columnar structure is a feature characteristic of all the sheets, whether distinctly intrusive or possibly surface flows. In nearly every instance it extends from the lower surface to the upper surface as it does from wall to wall in dikes. Structures of this type, however, are not confined strictly to sills. We find that

the flows of both Snake River and the Columbia River lava b exhibit the same type of structure. It must also be pointed out t with respect to the capping sheets we know only the base of sheet, and possibly its middle parts, the upper parts having be removed. There are also many localities where horizontal jointi is as well developed as the vertical jointing by which the colum structure is produced. In very many instances (three localities a east side of Pijitawabik bay, near Speke point on the east side Lake Nipigon, and on the west side of the portage into Waweig la from the south) this double system of jointing is well developed, a a moderate amount of erosion along the fissures has slightly round the exposed corners of the joint blocks so that the face of the cli sometimes for many hundreds of square feet, closely resembles ancient wall. The resemblance to a wall is very close and remar able because the individual blocks are strikingly uniform in size a re usually oblong in section, the horizontal joints being usuall closer to one another than the vertical ones.

On many of the thicker sheets so well is horizontal jointin developed that the vertical columnar structure which the cliff-front of these sheets present is largely due to the accident that they are i such a position that gravity, which causes some of the joint block to fall down the fronts of the cliffs while others remain standing a columns, happens to act in a vertical direction only.

SUMMARY OF THE EVIDENCE AVAILABLE.

In favour of Intrusive Sills.—The arguments in favour of regard- ing the 'caps' as intrusive sills may be briefly summarized:—

(i) Entire absence of any of those features that are usually associated with the upper parts of a surface flow—glassy matrix, amygdaloidal, porous, or basaltic texture, flow structure, associated volcanics, either lava breccias or pyroclastics.

(ii) A medium to coarse crystalline texture, usually indicative of a slow rate of cooling, such as would normally take place only at some considerable distance below the surface.

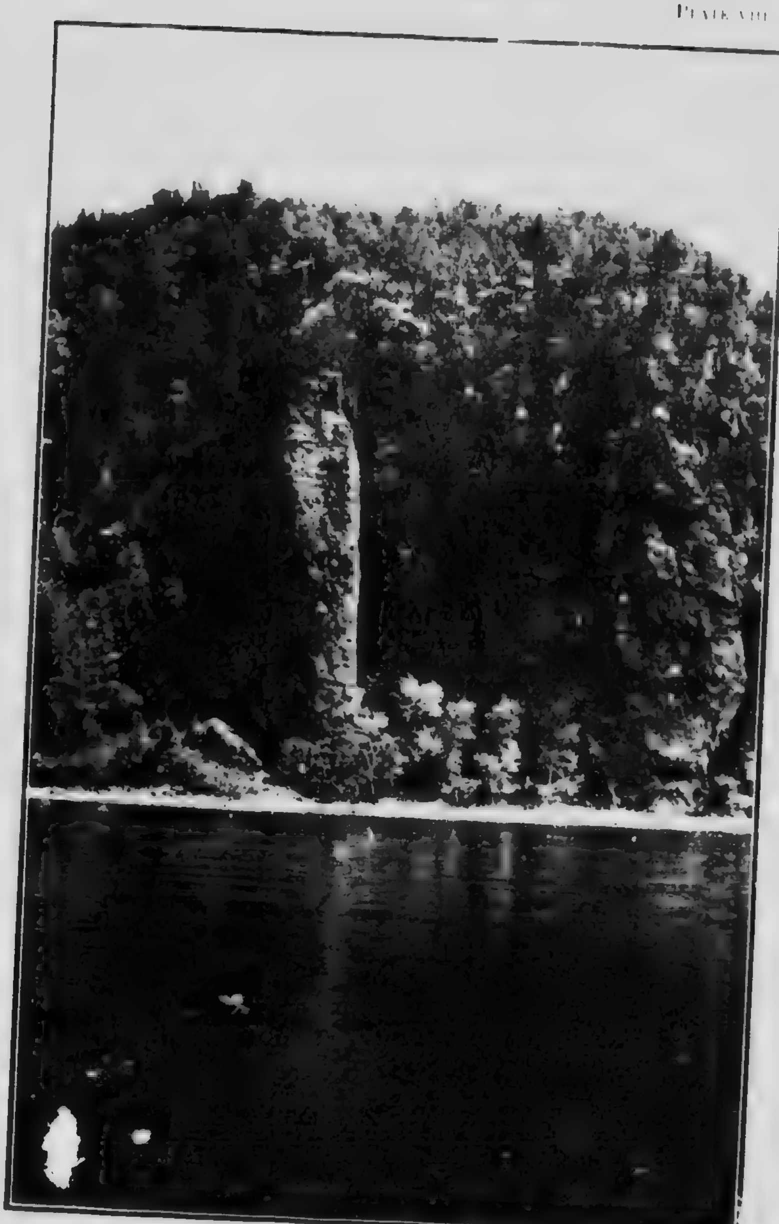
In favour of Surface Flows:—

(i) The very widespread occurrence of unconformities between diabase sheets and underlying formations.

(ii) The occurrence of boulders of granite and gneiss and schist in the diabase, the latter resting upon similar rocks in place in locali-

TYPES OF DIABASE TOPOGRAPHY.

PLATE VIII



"Chizel Rock," columnar diabase, east shore of Pijitawabik bay

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ties where there is direct evidence that before the advent of the trap the underlying rocks were buried beneath the sediments similar to those now present, near by, under the same diabase sheet.

(iii) The occurrence of old soils in place at the base and on the sides of sedimentary ridges, the whole being at times covered with a diabase cap.

(iv) The nicety of the adjustment by which the diabase sheets have fitted themselves to the underlying topography. While the upper surface of the residuals of the capping sheets are everywhere fairly uniform in height, the base of the sheet has adjusted itself to a topography where the relief was at times as much as 300 feet.[1]

(v) The mechanical problem which arises in explaining the numerous unconformities, especially those on the embossed Archean surface, by the theory of intrusion, vanishes completely on the theory of surface erosion prior to surface extrusion.

(vi) The features characteristic of the upper surfaces of sills—the occurrence of overlying beds or fragments thereof, aphanitic structures, included fragments of an old cover in the upper parts of the sheets—are not found.

(vii) The medium to coarse texture which characterizes the sheets would be found at the base of thick surface flows as well as in a sill, being dependent not on the nature and thickness of the cover so much as on the rate of cooling.

(viii) A glassy matrix, amygdaloidal or porous structure, basaltic texture, flow structure, and associated volcanics would not be characteristic features of the under parts of surface flows, and the upper parts of these sheets are unquestionably removed, without a single exception.

Balancing the Evidence.—It seems that we have no data relative to the actual character of the upper surface of the trap 'caps'; such negative evidence as is available is equally applicable to both theories. With regard to the texture of the residual basal portions of the sheets there are no recorded differences which would indicate that it belonged to a flow and not to a sheet. On the other hand numerous unconformities exist, and the diabases are known to rest successively upon Laurentian, Keewatin, Huronian (possibly middle, certainly lower and Animikie) and Keweenawan (lower, middle, and upper

[1] It is recognized that this even upper surface is now an erosion surface and that it does not necessarily owe its even character to an original uniform structural surface.

beds) and these unconformities are very widely distributed. Owing to the mechanical difficulties involved by any other interpretation it seems to the writer that the balance of evidence available is distinctly in favour of considering these capping sheets as the basal residuals of a once very extensive flow or series of flows of a very fluid diabase over the well dissected topography of a previous cycle.

Source and Nature of the Flows

Information about the source of the diabase is scant. No specific centres of eruption are known. Some of the sills in the sediments are found associated with the dikes of similar rock. Instances where the actual connexions between the two have been observed are rare, and the writer has never had the opportunity of studying one in detail. Two localities have been found within the Nipigon basin where the writer thinks that he has located a connexion between a dike from below and the overlying diabase cap. In both instances only one side of the supposed dike in contact with the adjacent rock was found, though the connexion with the sheet is distinct, and it cannot be regarded as certain that the intrusive is a dike from below.

One of these lies east of the south end of Black Sturgeon lake about three miles inland, near the head of a dry cañon cut in Keewatin schists. Near the head of this gorge, on the north side, the schists are found to *overlie* the diabase, an actual contact having been found. The contact occurs in the face of the cliff which forms the north wall of the cañon, and rises upward at an angle of about 20° from the horizontal, the exposed portion being about 125 feet in length. This diabase, here lying *below* Keewatin schists, is directly connected with the main sheet of diabase that covers all that section of country south of Lake Nipigon, and extends eastward beyond the Nipigon river. If this is a feeding dike the other contact lies farther east beneath the diabase sheet and would not now be accessible.

The second locality in which a possible feeding dike has been located is near the head of Pine portage on the Nipigon river, at the north end of the area of gneiss exposed in the gorge. Opposite the head of the portage are high bluffs of diabase, rising over 300 feet above the river. Near the summit we found a large mass of gneiss overlying the diabase, which forms the whole front of the cliff facing

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the portage. No actual contact could be found, though the two rocks were traced to within about 10 feet of each other. A small intervening hollow filled with loose soil obscures it. The contact seems to dip away from the cliff face and stands approximately at an angle of 45°, dipping towards the northeast. Since the gneiss here is part of the Archæan ridge to the south, that has unquestionably been buried in a flow of diabase, it is possible that the pre-existing topography was such as to bring about the relations here described without any intrusion from below in this locality.

A third locality of interest is Camp Alexander. About one mile below the steamboat landing, at the mouth of Bass creek on the west side of the river, a nearly vertical contact between diabase and granite occurs. Since the granite outcrops on the east side of the river the width of the diabase mass is about 400 yards, or less than a quarter of a mile. A number of outcrops show that it extends northward for about two miles. At the north end, part of it is spread out over the granite as a capping sheet. No conclusive evidence was found to show that the diabase at Camp Alexander and vicinity occurs as a dike. There is independent evidence showing that it occurs at the bottom of an old valley in the Archæan, and there is reason to suspect that the mass of diabase here preserved occupies a depression that was once a gorge in the valley floor.

Adjacent to the shores of Lake Nipigon there are several localities where wide dikes of diabase, similar to that in the sheets, occur. There are also numerous outlying large and small masses of diabase on the summits of Archæan ridges, on their sides and in the valley bottoms. In many instances it was impossible to find any actual contacts. In quite a few cases, particularly where the diabase lies at the summit or on the side of a ridge, sufficient actual contacts were found to show that the remnants were parts of sheets. With regard to some large masses of diabase, very coarse in texture (in one instance we found olivines more than an inch across), no contacts were found. While the coarse texture suggests slow cooling, the mass may have cooled slowly because it lay at the bottom of a hollow, and was thus deeper below the surface than the portions of the sheet lying above the adjacent hills; or it may have been more closely associated with the feeding dike and been the last to cool. In the majority of cases the textures of the more or less isolated and outlying masses of diabase are neither coarser nor finer than the textures of the different parts of the sheet in the main area.

While it seems probable that the diabase flowed out over the area from many fissures, very few of these fissures are known. The numerous outlying masses and ridges of diabase, scattered everywhere over the Archæan, to the north and northeast of the main area close to the bed of the lake, are often supposed to be the remnants of an extensive system of dikes. Detailed examinations of many of these have shown that so far as accessible contacts are concerned they are probably parts of sheets. Of course nothing is positively known about their cores, but one is justified in assuming uniformity on the Archæan topography. In many cases, between the detached remnants of sheets, or between these remnants and the main area of diabase, are wide dikes now unconnected with any sheets, but of similar rock. These dikes probably mark some of the channels through which the molten diabase ascended. Usually these dikes are not prominent topographic features, and the existence of a prominent topographic ridge of diabase cannot be assumed to be *prima facie* evidence that the ridge is the top of a dike.

The diabases are so widespread that we must infer that they were intruded at many different points, either simultaneously or successively. While only a few possible points of intrusion are known we can infer the existence of others. Still it must not be forgotten that in the Snake River fields flows of between fifty and sixty miles are recorded for lavas which solidified into basalt. Where the lava was fluid, as is indicated by the coarse crystalline structure and absence of flow structures, and remained quiescent for a long time subsequent to extrusion, and where the outflow was so great that even the small remnants of the sheets now left show a minimum thickness of over 600 feet for a belt more than sixty miles in length—under such conditions very few openings would suffice.

CHARACTER OF THE PRE-EXISTING TOPOGRAPHY.

Previous to the extravasation of the diabase the section of country lying south of the present Lake Nipigon was underlain largely by Keweenawan sedimentary rocks, with here and there exposures of older crystallines. In the basin of Lake Nipigon, and northward, there were numerous sedimentary remnants, outliers upon the Archæan. The Archæan itself presented that undulating and mammillated topography so characteristic everywhere along the margin between the sedimentaries and the earlier rocks. In fact the topo-

graphy was that of a belted coastal plain, modified in detail, but with an Archæan oldland to the northeast, and with numerous sedimentary outliers in the basin of Lake Nipigon. The main area of sediments lies south and southwest of the lake, and the first cuesta, that facing the oldland, can be traced from near the Canadian Pacific Railway line, lying west of the present Black Sturgeon valley, and continuing northwest to a point about twenty miles southwest of Nipigon House, where it turns southwest again. The present Black Sturgeon river runs along the lowland in front of the cuesta to within a few miles of the railway bridge, where it turns and enters the cuesta, crossing to Lake Superior through a gorge similar to that of a consequent stream.

DISTRIBUTION OF THE DIABASE IN THE LAKE BASIN.

In the light of the theory of the origin of the diabase capping sheets, which has been outlined above, the distribution of the rock and the thickness of the sheets in various localities may now be considered in more detail with respect to the Nipigon basin. The main sheet of diabase occupies the ancient lowland depression of the Nipigon coastal plain, and roughly forms a crescentic mass bounding Lake Nipigon on the south, southwest, and west. With small gaps where subsequent dissection has carved deep valleys[1] in the bottoms of which the earlier rocks are exposed, it extends in crescent form from Kaiashk lake on the east to beyond the Wabinosh river on the west. Southward and southwestward, remnants of the sheet form mesa caps on many of the prominent ridges found scattered widely over the area where the main mass of the sediments is still preserved, between Lake Nipigon and Lake Superior. Northward, practically the whole of the bed of the present Lake Nipigon is underlain by diabase, and beyond the lake as far as the Hudson Bay divide, mesas occur. Northeast of the lake one of the principal remnants of the main sheet forms the north and south peninsulas of Ombabika, and another large area, possibly a part of this sheet, occurs twelve miles farther northeast at Grass lake. Since the oldland gradually increases in elevation northeastward, it is doubtful if the northeast edge of the main sheet extended many miles beyond Grass lake.

At the south end of Pijitawabik bay the remnant of the sheet is at least 600 feet thick. Near the middle of the crescentiform main

[1] Pijitawabik bay, Nipigon River gorge, Black Sturgeon passage and several minor passages.

mass of diabase, at Tchiatang bluff on Black Sturgeon bay, it is at least 650 feet from base to summit. The remnant at Inner Barn island in Wabinosh bay is 600 feet thick. In all these localities, and in numerous other places not here indicated specifically, a careful examination was made of the sheet from base to summit, and, apart from the fact that at some points erosion has developed great benches, no noticeable change in the holocrystalline texture of the rock was observed, and no indication was found that would lead one to think that the sheet consisted of successive flows.

At the northeast angle of Lake Nipigon, on the peninsulas of Ombabika, and at Livingstone point, the thickness of the remnant of the sheet is about 300 feet, thinning to about 250 feet where masses of sediments underlie it. At various points around the margin of the oldland, remnants on the adjacent uplands vary in thickness from 12 feet, in one noted instance, to 150 feet. With regard to the masses of trap capping blocks of sediments on the cuesta to the southwest of the lowland, unless there is specific evidence to the contrary, it cannot always be decided whether they are remnants of an original capping sheet or are parts of sheets that have been intruded between sedimentary beds, the overlying beds and the upper parts of the sheet having since been removed by erosion. As intimated in the preceding paragraphs, however, the writer is inclined to regard the greater number of the 'caps' as remnants of an original capping sheet.

The relations of the thinner capping sheets around the lake basin on all sides of the lowland, to the main mass in the lowland, can be well comprehended by inferring that the molten diabase probably filled the lowland basin to overflowing, and then spread out on the adjacent higher ground on all sides. Undoubtedly some of the diabase came to the surface through fissures on the margin, and not within the basin, but the tendency would be for it to move toward the lower ground. Eventually the diabase from its several sources probably filled the whole of the basin, and spread far out on the adjacent uplands on all sides.

As to the maximum depth of the molten diabase over the lowest parts of the flooded lowland, no accurate figures can be given. An approximation based on the thickness of the remnants in the basin and of some outside of it, but immediately adjacent on the neighbouring upland, would place it at a minimum thickness of more than 1,000 feet.

Post-Diabase Dike Rocks.

At several places small dikes of a fine-textured aplite, or closely related acid rock, were found cutting the diabases, and more rarely intersecting some of the older rocks also. These occurrences are purely local in character and are rare.

On Black Sturgeon lake, at a point on the east side of the deep bay north of the long point, there is a dike, between 3 and 4 feet wide, cutting both the lower trap sheet and a mass of overlying sandstone. The dike is fine-textured aplite. It consists of pink feldspar, quartz, and some dark silicates, all in minute anhedra, the feldspar predominating. The hand specimen also happened to contain a flake of hematite $\frac{3}{16}''$ across, perhaps to be accounted for by the fact that beneath the trap sheet at this point is found the hematitic gneiss described above. At the locality where it was observed the dike strikes N 22° W. Close to this locality a small aplite dike, 2·5″ across, was found in the upper trap sheet and in the underlying sandstones. Neither the large nor the small dike could be traced very far, and it could not be determined whether the large dike also passed into the upper sheet of trap.

In the cliff front of Tchiatang bluff, on Black Sturgeon bay, there is exposed in cross section a dike about 60 feet in width, dipping 30° to the southeast, and striking N 62° E. The rock is much jointed into small polygonal blocks. It is green-pink in colour with grey patches, probably basic segregations, and it is very fine textured. The constituent minerals are pink orthoclase feldspars, black mica, quartz, and epidote. There are also a few small more or less contorted veins of quartz which may be of secondary origin. Two small apophyses of aplite were found running into the adjacent trap.

Similar dikes have been observed at Flatrock portage, at Livingstone point, and on the shore a little south of Ombabika narrows.

The largest dike at Ombabika narrows is about 2′-6″ wide, and could be traced inland for a considerable distance. The rock is a granodiorite containing a plagioclase feldspar related to oligoclase, a little orthoclase, and quartz. The diabase next to the contact was bleached as if by the action of the acid solutions.

Several other smaller dikes, some of them irregular in form, were found in this vicinity and on the island in Ombabika narrows. Some of them cut underlying quartzite as well as the diabase.

These acid dikes probably represent the last differentiation of the original magma penetrating the cracks and wider fissures in the cooling diabase and adjacent rocks. They are the most recent of the solid rocks of the region, with the exception of the veins noted below.

POST-DIABASE VEINS.

On the shore of Pijitawabik bay, about a mile south of Sandy bay and occurring along the shore for several miles, are a series of small secondary veins occupying joint cracks in the diabase. Usually the veins are less than an inch across, but a few were found at least 6″ in width. Some of the smaller veins are completely filled with white radiating fibrous pectolite. The wider veins are usually lined with radiating pectolite, but contain large quantities of prehnite in spherical crystal aggregates. Many of these larger veins show cavities lined with crystals of this latter mineral. Occasionally a more or less lens-shaped mass of white chalcedony is found in veins of either type.

It was reported that agates had been found on the beach in West bay, but we were unable to find either agates or any secondary veins in the diabase at this locality.

Pleistocene Geology.

The greater portion of the bed-rock in the valleys of all the rivers is covered by loose debris, chiefly of glacial origin. On the uplands, in the inter-valley districts, there are often large areas wholly free from cover of any kind and there are still larger areas with a very thin cover of scattered rock fragments, or little gravel and sand pockets, over which is spread a thin blanket of moss, and which supports only a small and stunted vegetation. On parts of the uplands the glacial cover may have considerable development, but it is never so extensive as in river valleys.

DEPOSITS OF GLACIAL ORIGIN.

The glacial deposits found within the area fall into two general classes, morainic materials proper, and classified materials, either in the form of eskers and kames, or of stratified deposits.

The morainic materials are of two types, terminal (or lateral) moraines and ground moraines, the latter being by far the most abundant—when considered areally. There are many localities in which unclassified glacial debris occurs where it is difficult to determine its origin. W[illegible] the materials of the ground moraine have overlain a ridge of tra[illegible] rock, the resulting heap may present all the surface features of th[illegible] mounds and hills which elsewhere in the region must be regarded as terminal deposits. Often it was impossible to reach any conclusion as to the character of a given ridge, but the frequency of the blanketed ridges the character of which can be determined, suggests that many of the mounds that appear to be of morainic origin may be otherwise formed. The identification of the morainic material is still further complicated by the superposition of classified materials both of glacial and of post-glacial lacustrine origin.

Terminal Moraines.—In the upper portion of the Poshkokagan River valley there are unclassified deposits consisting of trap boulders and a few of gneiss and granite, fragments of the country rock

(white dolomite), and sand and gravel, the two latter forming the bulk of the material present. These deposits, as exposed in cross section in the gorge of the river near the western boundary of the district, are about 40 feet in thickness. In the valley of the upper Spruce river very similar deposits are found at about the same longitude. In both cases the local surface topography is very irregular, being broken into domes and ridges, having a surface relief, in the Spruce River valley, of about 75 feet. Associated with these materials are mounds of sand, probably representing overwash sands from the ice front. The deposits of the Spruce river are hemmed in on either side by a cliff which rises about 50 feet above their highest level, the valley being about a mile and a quarter wide. It seems quite probable that these deposits represent the termination of a local ice tongue which lay in the valley now occupied by the Spruce river. Similar morainic deposits were found between the headwaters of the creek which flows northeast to Circle lake, and Lime creek, a tributary of the Poshkokagan.

This creek runs in a deep valley between trap uplands. The edge of the upland on the southeast side of the valley is in places scoured by glacial ice. On the opposite side of the same valley, near the upper end of the creek, is a large deposit of what seems to be remnants of pre-glacial soil in place. In the valley of the Poshkokagan the supposed local terminal moraine is also flanked by trap ridges which lie some miles away from the place where the morainic material was observed.

At the long portage above Camp Alexander on the Nipigon river, the trail runs over glacial debris. At the south end these deposits consist of stratified sands and clays, apparently overlying morainic materials, since boulders, sometimes of large size, are found in the channels of Frazer creek and the Nipigon river. Associated with these boulders are clays and gravels. At the upper end of the portage the trail descends over a slope covered with large and small well-rounded boulders, chiefly of trap, occasionally of gneiss. Some kettle-holes now form swamps in the upper part of the sandplain. The relations of the stratified and unstratified portions of the deposit suggest that this steep boulder-strewn portion of the deposit at the north end represents an ice contact slope, and that the stratified materials on the more southern part of the portage represent over-wash from the ice front. The deposit is further complicated by the presence of lacustrine stratified clays and fine sands along its front.

These deposits form a belt about two miles in width along the Nipigon river, and extend for a considerable distance on either side.

Farther up-stream, at Pine portage, glacial deposits of a somewhat similar nature occur. With them are associated two small well-defined eskers.

At the south end of Pijitawabik bay, blocking the channel leading south, are extensive deposits of glacial debris. They are also distributed over a considerable area on each side of the main depression, as it were, banked against the cañon walls on either side. It seems very probable that a local ice tongue also occupied this depression, that a considerable portion of the loose waste now forming the divide south of the bay was morainic material from this ice tongue, and that the superficial deposits on either side and to the south are overwash from the ice sheet.

It will be noted that terminal morainic material, partly covered by overwash sands and gravels, is reported in all the channels leading south and southwest from the basin, except the Black Sturgeon River valley. This valley runs approximately in a direction a little south of southeast, and lies transverse to the general direction of ice motion. In this valley, overwash gravels and sands are abundant, so much so that further special study would be needed to determine their extent, and to distinguish between them and the lacustrine deposits of later date, and to locate the morainic material which is probably buried beneath them. In other words, while it is very probable that terminal moraines exist, they were not distinguished as such in this valley.

Ground Moraine.—In the valleys of all the rivers, and in many places upon the uplands between the river valleys, is found a thin covering consisting largely of boulders, but sometimes associated with small amounts of arenaceous clay or with coarse sands and gravels. West of Lake Nipigon and the Black Sturgeon valley these boulders are almost always diabase, but east of the same depressions gneiss boulders somewhat more angular than the diabase boulders that are characteristic of the deposit elsewhere, are found. These *boulder pavements* or *boulder plains* cover in all several hundred square miles, and form a typical *felsenmeer*, obscured, it is true, in many places by moss and forest growth. In many localities this boulder deposit is masked by later stratified deposits, but in cross sections it is usually found to underlie them. The largest areal

development was found in the valley of the Poshkokagan river, where it covers fully 100 square miles. On the portage between Black Sturgeon lake and bay there is a typical exposure of this boulder pavement, simulating the features sometimes considered characteristic of the bottom of a river channel.

Smaller areas underlain by boulders are found in many places west and south of Lake Nipigon.

It is probable that some of the clay deposits that are found in the valleys of several of the rivers may be portions of the ground moraine. Some very small beds of this type have been noted in the valley of the Sturgeon river. Their area and extent are unknown.

Eskers.—In a few localities, eskers, or esker-like ridges, overlying the ground moraine, or associated with a supposed local terminal moraine, are found. Near the upper end of Pine portage in the Nipigon river, the trail for a short distance runs along the crest of a very stony esker-like ridge. Close to the upper end it crosses a second ridge, very steep and sharp crested, about 45 feet high, composed of angular blocks of trap, both large and small, and sand. The ridge strikes nearly north and south.

Esker-like ridges occur in many places throughout the district; they are usually steep-sided, sharp-crested ridges, composed of boulders and sand, or of sand and gravel.

North of Little Sturgeon lake there are a series of very sharp-crested parallel ridges, each averaging about 15 feet in height, and lying about an eighth of a mile apart. They consist of boulders and sand. The local topography seems comparable to that of areas in Sweden where esker ridges form natural boundaries between adjacent fields. The ridges in this locality strike S 74° E.

Numerous eskers and kame-like ridges have been reported by Moore as occurring near Trap lake in the Windigokan region, east of Lake Nipigon.[1]

Sandplains.—In the valleys of all the principal rivers, and in the hollows between the rock ridges in a number of other localities, are found deposits of stratified sands and gravels. The superficial areas of these plains vary from less than a square mile to many square miles. They differ among themselves in character, and are probably divisible into two distinct groups of deposits. The first group was associated with the period of ice retreat, and was formed at the front

[1] Moore, 18, p. 147.

or at the margin of the ice. Some of these were subaerial deposits of the nature of overwash alluvial fans, often of a very low slope on the upper surface, while others were of the nature of delta deposits, and were made in small marginal lakes lying in the more or less ice-bound hollows between the first uncovered rock ridges, while the main basin of the lake was still filled with ice.

The second group of sandplains belongs to the later stages of the ice retreat, when the whole basin was occupied by a glacial lake, the predecessor of Lake Nipigon. It is probable that the Nipigon basin formed a great northern bay from Lake Warren, one of the predecessors of the present Lake Superior, and that some of the larger deposits in the broader valleys adjacent to Lake Nipigon were made in Warren waters. Some of them are of later date than Lake Warren, and lie at levels below that of the present Lake Nipigon.

Except in a few specific instances, it is not always possible to determine the origin of a sandplain. The two types grade into one another, and all the sandplains of glacial origin do not develop the topographic characteristics of the typical glacial sand-plain. Strictly speaking, some of the sandplain types included here belong to a period subsequent to the Pleistocene, but as the forms grade into one another and cannot always be readily separated, as the process of formation was the same regardless of the time of formation, and as the Pleistocene gradually merges with the post-Pleistocene, it has been thought permissible to include the post-Pleistocene lake deposits with those of the earlier period when describing them and their distribution.

Glacial Plains.—In some cases, where the sand deposits occur in small areas, they are found to present steep typical ice contact slopes on the north or northeast sides. The average angle of the back slope is about 45°. The height of the crest varies in amount to a maximum of about 70 feet. From the crest outward the slope is gently downward at a low angle, rarely exceeding 5°, often much less than this, prevailingly in a southerly direction. On the steep back slope large blocks of loose waste are frequently found. Away from the sharp well marked crest line at the ice contact slope, stones of any kind are rarely seen. At the base of the steep slope, sometimes separated from it by a few hundred yards of flat, swampy ground, is usually a small stream; at times this stream runs directly along the base of the deposits. The plains are further frequently characterized

by the presence of large or small kettle-holes, representing spaces that were once occupied by large ice blocks around which the sands accumulated. Subsequently the ice melted and a depression in the surface of the plain was formed.

These plains are frequently of considerable local importance in determining the direction of flow of the smaller streams and in the distribution of forest growth. There is a progressive change in the type of vegetation as one descends from the upper, dryer, well drained portions of the plain, to the swampy, poorly drained areas underlain by the characteristic boulder pavement of the ground moraine. Deposits of this type occur at many points in the district, particularly south and west of the lake. The sandplain at Camp Alexander on the Nipigon river is a good example of this type of plain, somewhat complicated by the presence of terminal morainic material.

Lacustrine Plains.—Deposits of the second type cover large areas around the shores of Lake Nipigon, and in the valleys of the streams tributary to the lake. Very similar deposits in the Black Sturgeon River valley probably also belong to this type. The sediments are nearly horizontally (occasionally cross-bedded) bedded fine sands, often argillaceous. Associated with them are beds of fine stratified clays. Usually the stratified clays are found to underlie the sands, as if the clays had first been deposited in deeper water. Below Camp Alexander, in a freshly under-cut section of the east bank, were some of these clays resting upon stratified sands, and also capped by similar sands. The upper surface of these deposits is usually a plane inclined gently towards the basin of the lake or the lowest ground in the vicinity; locally it may appear to be almost flat.

In the valley of the Nonwatin river, near its mouth, sections about 25 feet in height are exposed through some of the deposits. The lower 10 feet above the surface of the river consists of very fine-textured bluish clay, apparently entirely free from grit. Somewhat similar clays were noted in the banks of the Black Sturgeon river below Eskwanonwatin lake. These clays were conformably overlain by stratified cross-bedded siliceous sands of very fine texture.

In the valley of the Kabitotikwia the sands are very similar in texture and composition, being, however, somewhat argillaceous. In the valley of the Poshkokagan the sands are mostly coarse, and are mixed with small rock fragments and occasional gravels. The sands of the Kabitotikwia form an approximately level plain extending

southward from Kaiashk bay to Chief bay, and lying between trap ridges; the width of the plain is about six miles. In the middle part of its course through this sandplain the river comes within a mile of Chief bay, and lies only 10 feet above the bay level. In the upper part of its course the river has cut down into these deposits about 50 feet, and the depth of the erosion decreases almost uniformly to within about 4 miles of Kaiashk bay, from which point the height of the adjacent plain is rarely more than a foot above water level. Along the margin of the river there are a number of poorly drained ponds which in position and outline suggest that they represent kettles on an extensive glacial sandplain. In the lower part of its course the river meanders through a very marshy district, the adjacent land being rarely more than a foot above water level. It seems quite probable that the fine silts of this part of the valley represent materials brought down by the river itself from the sandplain through which its upper course lies.

The lower three miles of the Poshkokagan River channel pass through similar alluvial deposits. The same is true of the clay deposit found at the mouth of the Nonwatin river, and on the Black Sturgeon river.

In the valley of the Black Sturgeon river the tributary lateral streams, or brooklets, especially those from the inface of the escarpment which lies to the west of the river through most of its course, have cut steep-sided flat-bottomed valleys to a depth, at times, as much as 60 feet below the general level of the sandplain which fills most of the valley. This plain, as shown by the sections in the valley of the main river which has in many places cut down to bed-rock, is not more than 40, and often less than 20 feet in depth in its lowest part. The surface of the sandplain rises inland towards the uplands on either side at a gradient somewhat steeper than that represented by the profile of the stream bed of the present lateral affluents in their lower portions, which are at grade. As a consequence, these young valleys at first deepen westward from the main river, and sections of greater depth are exposed along their sides than are found on the main stream. The whole thickness of the deposit seems to be composed of rather fine-grained argillaceous stratified sands. The width of the sand filling in the valley of this river varies greatly in different parts, but the average width is about one mile. In some sections shown along the Black Sturgeon river these stratified deposits are found to overlie typical ground moraine. In many

of the sections exposed by under-cutting, the beds are found to be horizontally stratified clays; where they occur together the clays were always found to underlie the sand. At one point, 6 miles south of Eskwanonwatin lake, on the east side of the valley, a sharp razor-backed esker, striking east and west, and 70 feet in height above the plain, was noted. Other esker-like or kame-like ridges of uncertain origin were noted near the base of the escarpment north of Nonwatin lake.

A sandplain of considerable importance occurs at the bottom of McIntyre bay, and forms the site of the Indian settlement. At the shore section about 30 feet of fine reddish sand is exposed in a cliff.

Similar deposits cover a large area at the head of Lake Helen. On the east side of Nipigon lake, around Poplar Lodge, and in the valley of the Sturgeon river, a very extensive series of deposits of this type occurs. In a section above the first falls on the Sturgeon river, Coleman found 'seventy-three feet of silt, followed by a layer with angular boulders like till, as if the silt were inter-glacial, but the slipping of materials on the cliff above made the relations somewhat uncertain. Above the bouldery bed was a stratified sand reaching ninety feet above the river.'[1]

These deposits are also found in the valley of the Onaman river, in the valley of the Ombabika river, and at the north end of Ombabika bay. A very extensive sandplain occupies a large section of country north of Lake Nipigon between the Pikitigushi and the Whitesand rivers, and extending northward nearly to Round lake. In fact this is the largest area of alluvial soil suitable for occupation within the boundaries of the district. The Pikitigushi (Mud) river gets its name from the character of the materials through which it has cut its channel. The edge of the deposit has been cut back by the waves of Lake Nipigon, and it shows an extensive cliff of white sands, rising nearly 100 feet above the lake. The channels of the Pikitigushi and Whitesand rivers have also exposed sections of this deposit about 100 feet in thickness. The plain rises gently northward at a rate less than 5 feet per mile; over large areas it appears to be nearly flat.

Other smaller sandplains are found near the west end of Wabinosh bay, and at the mouth of Kaiashk river. The latter is the site of an Indian reserve and village.

[1] Coleman, 6, p. 169.

PLATE X

6618 p. 110

R[illegible] island, [illegible] the [illegible]

[illegible] R. H[illegible]

CHARACTER OF THE ICE EROSION.

Striated Rock Surfaces.—Rounded and glaciated rock surfaces are found nearly everywhere throughout the region. Surfaces on which striæ are actually preserved are comparatively rare. In most cases the rocks are too much weathered and lichen covered to show them; in other cases if the covering of mois moss is removed it will be found that the underlying rock surface, though possessing the general rounded outlines of a glaciated knob, has been eaten and roughened by humic acids to such an extent that all the striæ have disappeared. This disintegration is greatest on sloping surfaces where there is a small amount of local drainage, but where the rock is kept constantly moist by damp moss. On such rock surfaces as have been protected by a sand or clay cover from the circulating soil waters the striations can often be found. They are also preserved on such rocks as are little affected by humic acids, *e.g.*, rocks of the Iron formation. Surfaces on which striations are best preserved are those which have been subject to the wash of waves or streams. They are particularly well shown along the east shore of Lake Nipigon.

Here, as in many other localities, local topography is found to have influenced the local direction of ice motion as indicated by the striæ. All who have examined the striæ have noted that there are two sets, one preserved only in hollows and sheltered spots around the shores of Lake Nipigon, the other the prevalent type. The former are well shown at many points along the east shore of Lake Nipigon, especially so north of the mouth of the Sturgeon river. Their course lies between 190° and 215°, or somewhat to the west of south. The younger series of striæ are found at numerous points around both sides of the lake, and lie between 250° and 280°, that is, they have a pronounced westerly trend. Striæ in a direction other than the dominant one are often found where variations in local topographic features have locally modified the direction of the movement.

On the upland areas away from the lake basin, striæ are rare. The writer has observed a number on the upland south of the lake and east of Black Sturgeon lake, and also near the headwaters of a tributary of the Poshkokagan river. Their trend is between 210° and 215°, or in accord with the older system of striations which are found on the northeastern shores of Lake Nipigon.

In general, it may be said that so far as one can judge by the study of striated surfaces, the striæ in the basin of the lake have a

pronounced westerly trend, while outside of the basin the trend is south of southwest. It can be inferred that the southwest movement as indicated by the striæ represents the general direction of the ice motion during that period of time when the front of the ice lay south of Lake Nipigon basin. The westerly trend of the striæ in the basin may be due to local vortical movements in the ice due to the nature of the topography of the basin as a whole, but it is more probably due to movement of the ice in later stages of the glacial period when much ice still occupied the Nipigon basin, but when active movement on the uplands had ceased.

In a few localities chatter marks and crescentic cross fractures are well developed on smoothly glaciated surfaces of fine-textured rocks. In the narrows leading to Ombabika bay, and near Spruce point on the west shore of the lake, some particularly fine examples were seen.

Extent of the Ice Erosion.—Numerous investigations have shown that the type of topography characteristic of the ancient crystalline rocks of central Canada around their southern margin was developed prior to the deposition of the now overlying sediments. It is also known that before these sediments were deposited, but after the rounded hummocky surface had been developed, a certain amount of surface erosion and disintegration had taken place. Whether this type of topography is to be attributed to the action of glacial ice or not is a subject requiring further discussion, and one which does not come within the scope of this report; but in view of what is known about the topography of the crystallines beneath the sediments and close to their margin, it is almost certain that the amount of erosion to be attributed to the last ice sheet, so far as this area is concerned, is not very great. Those who attribute an enormous amount of erosion over all central Canada to the last glacial period wholly fail to appreciate the nature of the surface beneath the sediments, and also the property possessed by the ice sheet of differential erosion. Locally the effective power to erode may be concentrated, while over large areas little erosion, be[illegible] the removal of loose waste, and sometimes not even that, may [illegible]en place.

Where local erosion has been intense the[illegible] usually some obvious reason to account for the concentration of the ice action at that place. One of the most striking of these places found in the Nipigon basin is at Ombabika narrows at the northeast corner of the lake.

Here high cliffs of diabase on either side of the narrows have so guided the ice that, as it were, a stream coming from the northeast has passed through the narrows. The resultant action of this concentrated ice stream on the underlying rock bed over which it flowed is shown in the clean, smooth surface which the erosion produced at this point. Some of the best examples of chatter marks and concentric fractures, due to the irregular slipping of the rock blocks caught in the base of the ice sheet, are shown at this place.

The actual amount of solid bed-rock that has been removed from any place in the district cannot be very large, because nowhere is there any marked discordance between the profile curves of the surfaces of the crystallines under the trap sheets where the ice never reached them, and the similar profile curves of adjacent surfaces where the ice has polished the bed-rock. This lack of marked change in the character of the contours of buried or recently uncovered portions of the crystalline floor, when compared with the contours of glaciated ridges of the same rock closely adjacent, is a negative argument of some weight showing that the erosion has not been very extensive.

One of the most characteristic features of the district is the prevalence of steep escarpments and cliffs forming the edges of the diabase sheets. In many instances there are piles of talus at the base of these cliffs; while in only a few instances does the talus reach to the crest. There are many cliffs which have no talus at all, or only a very limited amount. Some of these are ice polished from base to crest. Other cliffs only show ice polishing and rounded edges near the crest. As a general rule, it may be stated that only those cliffs are glaciated which have been exposed to the thrust of the advancing ice sheet.

Now the presence of an ice-polished front shows that at these points the retreat of the cliffs since the glacial period has practically been nil. The absence of talus beneath the ice polished part of the cliff, even where it may be polished from base to summit, shows that the talus which must have existed before the ice came must have been removed. Now the interesting point is that in several places where there are several miles of cliffs exposed to the thrust of the ice there are alternate portions showing talus and polished fronts destitute of talus, or with talus only below the level of the polishing, and the talus is of pre-glacial age and is cut off at the base in line with the polished front. It was not all removed, as was that which must have been in front of the polished parts, because

it occupied a slight re-entrant in the lee of the est of the cliff. [1]The upper and lower portions of one of these curtailed talus piles show non-accordant contours and profiles. Talus piles in the lee of cliffs where they were completely protected are untouched and have normal profiles. Talus piles are also found with the lower part buried beneath sandplains.

In one locality, as already noted, in a valley about 300 feet in depth, cut in a trap sheet, and lying a few miles southwest of Circle lake, there is a small area of disintegrated diabase which seems to be in place. The thickness of the deposit is at least 20 feet, though it may be greater. The material consists of a diabase gravel without a trace of bedding or stratification. The pebbles are each rarely over half a cubic inch in volume, and with them are found a few small but not disintegrated blocks of the original rock. The exact extent and thickness of the deposit was not satisfactorily ascertained on account of the very dense undergrowth with which it was covered. Glacial sands overlie it, the exposure being seen along the side of the creek valley, which lies in the lee of the trap bluffs. There are also many other localities where the partially disintegrated diabase is still in place, though nearby surfaces still retain the marks of glaciation so well preserved that the conclusion seems to be warranted that much of the decay took place prior to the period of ice advance.

The materials of the ground moraine, particularly the portion of it which is characterized by the presence of numerous loose boulders, are largely the same as the bed-rock on which they rest, from which it is inferred that much of it has not been transported very far. Where the boulders are diabase they are usually well rounded, showing that the movement has been sufficient to remove the partly disintegrated portion of the rock on the corners and edges of the joint blocks.

In general, the action of the ice seems to have consisted in the removal, transportation, and re-deposition of the loose debris, with only a very limited amount of bed-rock erosion, except in the few localities where the action, from local causes, became more concentrated.

ORIGIN OF THE SOIL WASTE.

The coarser materials were derived from the rocks in place near the locality where they were found. The greatest areas of boulder

[1] Tchiatang bluff, Pijitawabik bay and elsewhere.

PLATE XI.

Diabase boulder, east shore of Pijitawabik bay, Lake Nipigon. Probably moved to its present site by the action of shore ice.

PLATE XII.

Falls on the Blackwater river, three miles below Macinakigo lake, and twelve miles east of Lake Nipigon.

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pavement are found southwest of the districts where the talus piles have been removed from the bases of the bluffs, and most of the boulders of the pavements are probably derived from these talus piles. The gravels and sands are largely quartzose materials derived from the disintegration of the Archaean crystallines, transported, sorted, concentrated, and deposited by stream action. The finer silts and clays probably represent the disintegration products of the feldspathic constituents of the crystallines. These finer materials have in many cases been worked over several times during and since the glacial interval.

Mingled with the waste of purely local origin must be some that has been transported by the ice from nearer or greater distances. Some of the waste undoubtedly came from beyond the Hudson Bay divide, towards the northeast. Parks found limestone pebbles carrying a small Atrapa, crinoid columns, indistinct Bryozoa, and corals, on a small island in Cameron lake, east of Poplar Lodge.[1] The pebbles occur in an argillaceous gravelly sand deposit. The writer picked up two worn cherty pebbles on a beach on the east shore of Pijitawabik bay, which contained fossils. Mr. Lambe has identified these as *Pycnostylus elegans*, Whiteaves, and *Favosites gothlandica*, Lamarck. Both species have been recorded by Lambe from Southampton island, and by Whiteaves from the Ekwan river. *P. elegans* is characteristic of the Guelph limestone of Ontario. So far as the writer is aware, these are the only pebbles that have been identified as coming from the Hudson Bay Palæozoic basin. Some fragments of limestone were also found about 2 miles south of South bay, along the tramway, that may have come from the Hudson Bay slope, but no fossils were found in them. The minimum distance that they have been transported is about 150 miles, from the Silurian area that is known to occur in the basin of one of the larger tributaries of the Albany river from the south.

[1] Parks, 23, p. 60.

RECENT DEPOSITS.

All the principal streams are building alluvial deposits at or near their points of discharge into the main lake. Some of these deposits, particularly on Lake Nipigon, cover very large areas, stand only a few inches above water level, and are covered with aquatic or semi-aquatic vegetation.

Along the shores of the lakes the usual sand and gravel beaches are found in the bottoms of most of the bays on all the lakes. In places sand spits, barrier beaches, and other features characteristic of shorelines at certain stages in their development, are found. These features are only of local occurrence, and are not, at the present time, of sufficient importance to be described in detail.

MARL AND PEAT.—Another group of deposits, which may at some time be of economic importance, are the marl and peat beds now forming on the bottoms of some of the upland lakes and swamps. One of these is Sucker lake, about four and a half miles west of Eskwanonwatin lake on the Black Sturgeon river. The average depth of the lake at the time of our visit (September, 1901) was about 12″ or 14″. The maximum depth that we noted in a number of soundings along what seemed to be a stream channel was 6 feet, but over the greater part of the lake the depth was between 6″ and 8″. In many places it was impossible to reach the shore at all, and for several miles in our course around the lake the canoe was forced through the slime forming the bed of the lake. The water had a somewhat sulphurous taste and disagreeable odour due to the decomposition of a species of *Chara*, which everywhere is found growing over the bottom. The depth of the deposit of marl now forming was not ascertained, though it is certainly over 6 feet. The material seems to consist of calcareous casts of *Chara sp.* mingled with carbonaceous material.

Many small ponds and swamps are known, some of considerable area, in which gradual accumulations of decayed mosses and other vegetable waste are taking place. None of them have been studied or investigated.

STRUCTURAL GEOLOGY.

Folding and Plication of the Archæan.—Attention has largely been drawn to the structure of the Archæan rocks, and to the general notheast-southwest trend of the Keewatin series and of the gneisses of the Laurentian. The belted arrangement of these earlier rocks, the metamorphic structures developed in them, and the relations which exist between the acid and basic members of the series, afford the only evidence available of the operation of mountain building forces in this region at a time long before the period when the Keweenawan sediments were deposited. These structural features, so early developed, still exercise a dominant control over the topographic development of the region. During the very long interval which has elapsed since the planation, which removed the upper portion of the early mountain chain and produced the nearly even surface upon which the later sediments were laid down, structural changes have been very slight.

Block Faulting.—Some of the nearly horizontal beds of sediments have been slightly disturbed by block faulting subsequent to the period of invasion by the trap sheets. It is quite probable that these faults were first developed in the region prior to the deposition of the sediments, and that later readjustments of the crystalline surface caused the early fault lines to be developed also through the overlying sediments. In any event the continuity of the beds of the sedimentary series has been disturbed by a number of faults.

The region appears to have been divided into a number of blocks by the fault systems, and these blocks are usually slightly tilted towards the northeast. It is only rarely that the fault plane forming the tilted blocks can be located for any distance, because shattering along these planes has rendered the fronts of the uplifted blocks particularly subject to erosion, and the fault zone is usually buried under waste.

Faults on a small scale are often seen in the sediments, and in many cases these appear to be directly associated with the intrusion of the diabase sheets.

In two localities the loci of lines of faulting appear fairly well established; the gorge of the Nipigon river is one of these, the other lies along the escarpment east of Black Sturgeon lake and north of Nonwatin lake.

On the Nipigon river above Lake Jessie the cliffs on the east side stand about 200 feet higher than those on the west. At Island portage, and in that vicinity, there is also exposed from beneath the diabase which forms the cliffs through most of the gorge, a ridge of Archæan rocks. The cliff on the east side here is gneiss; on the west side gneiss occurs on the island and also on the main shore at the base of a granite ridge. This granite ridge is also capped by diabase, but it stands at a much lower elevation than the gneiss on the east. Hence it appears that the gorge of the Nipigon river lies along the locus of a fault zone, and that movement on that zone has brought about the marked difference in elevation between the east and west sides of the gorge.

In the Black Sturgeon Lake district there is a strong escarpment formed by trap-capped crystalline rocks. This escarpment may be traced southeast from Tchiatang bluff to below Eskwanonwatin lake. At a number of points, particularly north of Nonwatin lake, a breccia composed of fragments of crystalline rocks cemented with hematite is found at the base of the bluff. Red Keweenawan sandstones lie close to the foot of the bluff, seemingly much brecciated; in some places a deep valley has been cut between them and the foot of the cliff. Wherever the sections have been studied the red sandstones overlie white sandstones, and hence it is improbable that the red sandstones at the foot of the bluff represent the base of the series. On the top, and at a little distance from the edge of the escarpment, basal conglomerates, white sandstones, and pink sandstone, in the order named, are found in place resting upon the crystallines. It seems very probable that this escarpment is formed by the edge of a fault block. The displacement has here been over 400 feet. The eastern edge of this block forms the west side of the Nipigon gorge.

While it is probable that other faults occur in the district, they have not been noted.

Folding.—The Keweenawan sediments usually occur in nearly horizontal beds. At Cooke point several small low anticlines were found in dolomites. The dolomites are covered with diabase, in a sheet about 120 feet thick, and the anticlinal arches project upward

into the diabase. No dikes were found in the dolomites, though they may occur. The folds may have been caused by their intrusion, or, as seems more probable, in the absence of any evidence that dikes are present, they may have resulted from the expansion of the dolomites when heated by the molten traps.

Joint Systems.—All the rocks are traversed by systems of joint fractures, and these are particularly well developed in the diabase sheets; they have already been described in connexion with those sheets.

The jointing and all the observed faulting appear to be of later date than the invasion of diabase. They may in part be accounted for by the settling of the beds and the readjustments that took place when the diabases were cooling, and after they had been removed from beneath. As already noted, it is not at all improbable that the general lines of faulting had already been developed long before, and that movement along these planes was renewed when further readjustments became necessary to restore the conditions of equilibrium that were disturbed by the extravasation of the diabase.

PHYSIOGRAPHY.

General Sketch.

There is a very intimate connexion between the topographic features of this region and the geology; each formation found in the district nearly always has its own characteristic features. Lake Nipigon occupies the lower portions of a basin-like depression; east and north an extensive area of the Laurentian peneplain is developed; south and west are highlands underlain by diabase and sediments. These latter areas are not simple topographic units, however, but are complicated partly by block faulting and partly by the dissection that has taken place. For the purposes of study and description, the following physiographic areas may be distinguished:—

Laurentian Peneplain division.
Lake Nipigon lowland.
Black Sturgeon lowland.
Southeastern plateau.
Central plateau.
Western upland.

Physiographic Areas.

LAURENTIAN PENEPLAIN.

GENERAL FEATURES.—The characteristic topography of the Laurentian peneplain is developed over all the area underlain by Archæan rocks. The region is characterized by the prevalence of low rounded domes and ridges of crystalline rocks, absence of soil cover in place, moderate relief rarely exceeding 100 feet and developed over areas of complicated rock structures, and a remarkably even sky-line, here and there interrupted by some monadnock rising above the general elevation. As intimated in an earlier section of this report, the Archæan crystallines underlie all the rocks of the district; the dominant topographic features of the crystallines are also believed to have been developed prior to the deposition of the sediments that now occur here.

East of Lake Nipigon, the country rises to about 550 feet above Lake Nipigon at Kaiashk lake; towards the northeast, at Summit lake,

the elevation is about 250 feet above the lake; west of the lake, beyond the area mapped, the plateau of Archæan rocks stands about 700 feet above the Nipigon basin. Archæan rocks are known to outcrop in the bottom of the basin, and also in the country to the south towards Lake Superior. There seems to be high ground both on the east and on the west, with a depressed basin between. There is also a gradual slope from the Hudson Bay divide down this depression towards Lake Superior. Hence there seems to be a marked sag or trough-like depression, very wide, and very shallow, on the surface of the crystallines, slightly inclined southward. This depression is probably about 450 feet below the level of the nearer portion of the Archæan uplands both east and west, and about 125 miles across. Its southern end is blocked partly by sediments, partly by diabase, and in part by block faulting; Lake Nipigon owes its existence to this blockade.

Within this broad basin there was developed, near Lake Superior, in pre-Palæozoic time, a deeper inner valley. The trough-like basin which is occupied by Lake Helen and the lower part of the Nipigon river is a portion of this inner depression. Its sides were much steeper than the general slope of the peneplain. At the present time the tilting of the Central plateau block to the west of it has only very slightly increased the slope of the west side of this valley, which is now over 100 feet per mile. The slope on the eastern side of the depression is much greater than this. The depression is approximately 8 miles across. On the west side of this inner valley, in the township of Booth, there are sandstone beds in place in nearly horizontal beds, resting on the crystallines and capped by diabase. Diabase also occurs in the very bottom of the depression resting on the Archæan rocks.

MESAS.—Scattered here and there over all that part of the Archæan which occurs in the mapped area, are a number of steep-sided, flat-topped ridges or mesas, formed by remnants of diabase sheets. Around the margin of Lake Nipigon some of these mesas are underlain by sediments, but away from the lake they usually rest directly on the Archæan. These ridges rise from 100 to 300 feet above the general level of the surrounding country.

DETAILED FEATURES.—In detail, the Archæan areas are characterized by the presence of numerous elevations and corresponding depressions between the elevations, producing what may be called a hum-

mocky or mammilated surface of low relief. Where the rocks possess gneissic or schistose structure the ridges usually have a dominant trend in the direction of the strike; the finer-textured fissile rocks usually develop long, narrow ridges, while the massive granite areas are characterized rather by the prevalence of domes.

Many of the lower parts of the hollows between the ridges are only partly drained, and are filled with water to the level of the lowest sag in the bordering ridges. The region is thus also characterized by the presence of numerous lakes, usually small, and often of very irregular outline where the level of the local water table is such that the water in a number of the small basins becomes confluent and forms a single large lake. The basins drain from one to the other, forming a complicated drainage system, the inter-lake streams being usually characterized by numerous rapids and falls. The presence of glacial deposits in nearly all the depressions tends to simplify the drainage systems which have developed, since many of the trough-like rock basins have been so far filled with waste that the drainage flows through them in well-defined channels cut through this waste, without forming lakes.

Northeast of Lake Nipigon the highest ground is that underlain by the Laurentian rocks. The character and structure of the Keewatin series has led to the development of well-defined longitudinal systems of ridges and depressions, with corresponding drainage features. The three largest rivers tributary to Lake Nipigon from the east pass over the Keewatin area through the lower parts of their courses, occupy well developed basins in these rocks, and incidently receive much of their water supply from adjacent Laurentian areas. The lower courses of all of these streams lie through glacial and lacustrine deposits which occupy the lower parts of the trough-like depressions in which the rivers flow. The depth to which the streams have eroded their channels in the glacial waste has been determined for each stream by the thickness of the deposits over buried rocky ridges. In each of the rivers there are a number of rapids and falls developed at the points where buried ridges have been uncovered, and each ridge thus discovered has acted as a local base-level controlling the depth to which the stream could erode the soft deposits for the section of river which lies next above. Both the Blackwater and the Onaman, which lie at the south and north edges respectively of the Keewatin area, in parts of their courses occupy new channels cut in bed-rock. The Sturgeon occupies the lowest

portion of a great median depression, and is characterized by a smaller number of rapids and falls.

Lake Nipigon Lowland.

The Laurentian peneplain gradually merges with the lowland around Lake Nipigon, so that on the east and north shores of the lake there is no marked difference in the character of the topography from that found several miles away from the lake shore.

The greater portion of the bed seems to be underlaid by trap rocks, though on the north and northeast the Archæan rocks pass below water level, and are exposed at many places on the shores. The nature of the bed of the lake may be inferred from the character of the upper surfaces of the trap sheets on the uplands, and on those portions of the lowland which are not below water level. It is usually a gently-rolling surface of low relief, characterized by the development locally of sharply-marked ridges and hollows. Here and there massive residuals stand at a considerable elevation above the general level, and in a few cases deep cañon-like valleys are cut into the plain; some of these depressions are over 100 feet in depth and their extent is unknown. The general character of the upper surface of the trap sheets is such that an interval of peneplanation to a local base-level may be inferred, during which interval a large amount of rock was removed, a few residuals, now forming prominent mesas standing as much as 600 feet above the general level, being left; subsequently during a period of local depression of the controlling baselevel of erosion for the district, deep cañons were cut below the earlier peneplain level, and dissection began again.

Lake Nipigon is characterized by the presence of numerous islands, the greater number and larger of which occupy the middle of the lake, forming a chain of islands stretching up the centre and dividing the lake into two distinct basins, with a large area of shallow water between. These islands are the unsubmerged portions of the higher parts of the lowland plain, and many of them are erosion residuals that stand above the level of that plain.

There seems to be a deep channel running along the eastern part of the lake in a north and south direction, and there are very few islands. McInnes records a depth of over 400 feet about 2·5 miles southeast of Livingstone point.

The water of Lake Nipigon is usually either clear and of a pale blue colour, or slightly whitened in places as if there were a small amount of very fine clay in suspension. Along the north shore, and in some of the larger bays where there are extensive deposits of fine clays and sands along the shores, the water often becomes locally discoloured. All the streams tributary to Lake Nipigon contribute brown-tinted water, but this rapidly becomes decolorized when it enters the lake and mingles with the lake water. The present name of the lake, Nipigon, is a contraction of the older name 'Alemipigon,' an Indian name signifying 'deep clear water.'

Black Sturgeon Lowland.

In the vicinity of Black Sturgeon lake, and west of this for about 12 miles, is developed another lowland. This lowland extends southward as a narrow valley through which the Black Sturgeon now flows. It is bounded on the west by a well-defined cuesta formed by the trap-capped Keweenawan sediments. This escarpment can be traced from within a few miles of the Canadian Pacific Railway bridge over the river to a point about twenty miles southwest of Nipigon House. The southern part of the lowland is bounded on the east by a plateau formed by an uplifted block of Archæan rocks. Towards the north this lowland becomes confluent with the lowland around Lake Nipigon.

This lowland is largely underlain by diabase, and as in other cases, there are numerous mesas standin between 100 and 400 feet above the general level of the lowland. The whole lowland rises gradually towards the west and the foot of the bounding escarpment. There are a number of shallow lake basins developed on its surface, the largest of which is Little Sturgeon lake, and a few cañon-like depressions, now partly blocked by glacial waste and forming long narrow lakes, are known to occur. It is drained by a number of small rivers which are tributary to the Black Sturgeon river. Through most of their courses these rivers occupy young post-glacial channels.

Southern Plateau.

That portion of the main diabase sheet which lies east of the Nipigon river forms a plateau standing over 600 feet above the level of Lake Nipigon. The upper surface of this plateau is undulating or rolling, and is inclined southward at a low

angle. There are only a few small lake basins on it, and little trickling streams. The Pijitawabik valley divides it into two parts, but as both sides of the valley stand at the same elevation, and as the valley itself has every appearance of being due to [illegible] erosion, there is every reason to believe that this plateau is a single fault block. The plateau is only slightly dissected on its margins; it is cut into three distinct parts by the Pijitawabik gorge and another deep cañon tributary to this gorge from the east.

Central Plateau.

Between the Black Sturgeon lowland and the Nipigon river lies a tilted plateau block. On its western edge this block stands about 700 feet above Lake Nipigon. Farther south the elevation is about 400 feet. The northern part of the plateau is underlain by diabase, the southern part shows chiefly Archaean rocks above which occur diabase residuals that protect some underlying sandstones. The topography developed on each section of the plateau is that characteristic of the underlying rocks for the district. The northeast corner of the plateau dips towards Lake Nipigon and descends to about 50 feet above it.

Western Upland.

The east edge of the western upland is formed by the cuesta already referred to when describing the Black Sturgeon lowland. The inface of the cuesta is steep, and often presents a raw cliff face. The cuesta is capped by diabase. There is reason to believe that the Black Sturgeon lowland and this cuesta to the west were developed by the dissection of the sediments prior to the extrusion of the diabase sheets. The general type of topography is that characteristic of a belted coastal plain. The greater portion of the upland within the boundary of the map sheet drains towards the Black Sturgeon lowland by streams which pass through the cuesta front in steep, narrow, new channels.

Drainage Systems.

Pre-Glacial Drainage.—While the present Nipigon basin drains southward through the Nipigon gorge, in pre-glacial days there were probably two systems of drainage.

Approximately all that portion of the basin east of the line formed by the larger islands in the middle of the lake, probably drained through the Pijitawabik valley to Lake Helen and southward, following the line of the trough-like depression in the Archæan floor. The comparatively steep slopes found along the whole eastern shore of Lake Nipigon, wherever the crystallines are exposed between the northern part of Lake Nipigon and Lake Helen, are possibly the east side of this depression, which is completely uncovered only at Lake Helen.

The Black Sturgeon lowland probably drained in the same direction as it does to-day. Tributary to this drainage system from the lowland basin would come a large portion of drainage from the Nipigon Lake basin west of the central line of islands. The main drainage channel appears to be indicated by the lowlands which extend southward from north of Kaiashk bay, through the depression in which the lower part of the Kabitotikwia flows, to Chief bay and thence to Black Sturgeon lake.

The dissection of the plateau blocks was well advanced prior to the ice invasion. On the blocking of the earlier outlets of the region partly by the ice and its deposits, possibly in part owing to slight crustal movements, the basin as it is now developed was formed.

It is probable that streams had already partly developed the Nipigon cañon before the glacial period. Its upper portion flares northward, while at the head of Lake Jessie it gradually widens southward. Glacial debris and glaciated surfaces are found at both the upper and lower ends of the cañon, and while the side of the gneiss escarpment that lies on the east is striated, there is no evidence on record to show how far down into the cañon these striations extend. The surface of the gneiss island at water level in midstream and in the middle of the cañon appears to be glaciated, but the action of the river ice for centuries might have produced a similar effect. Still the writer regards the cañon as probably of inter-glacial date.

The dissection of the margins of the diabase sheets in the plateau blocks had led to the development of the very complex system of re-entrants and valleys tributary to the main drainage system. The present lake owes its very intricate shore line to the flooding of these pre-glacial topographic features by the waters of the lake consequent on the partial blocking of all the older drainage lines.

MODERN DRAINAGE—GENERAL FEATURES—Lake Nipigon is the catchment basin for a radial system of streams which collect practically all the overflow from the neighbouring regions. Those streams which drain the Laurentian peneplain area, where they do not flow in depressions partly filled with glacial waste, are characterized by the presence of a series of lake basins and short rapid connecting streams. The presence of fine-textured loose waste in the larger longitudinal depressions of the peneplain has led to the development of well-defined stream valleys in which there are only a few lake basins. In those portions of their courses which lie through such valleys the streams meander more or less; falls and rapids are developed chiefly at those points where the dissection has gone deep enough to discover buried rock ridges.

Rivers from the southwest flow in deep valleys cut through diabase and sediments, and are for the most part characterized by the presence of long stretches of shallows and rapids. Several streams drain lakes which lie upon the western upland. Where the streams come through the cuesta they usually have cut narrow steep-sided gorges in the diabase and in the sediments. The gorge of the Poshkokagan is about 140 feet in depth; that of the Spruce river is about 100 feet in depth, though from the summit of the adjacent trap ridge to the bottom of the gorge is over 400 feet.

In the Spruce river, the upper part of the stream above the gorge flows in a new and narrow channel cut in red dolomites, and lies at the lowest portion of a broadly open valley. The form of this valley suggests that it originally drained towards the southwest. The gorge is a narrow chasm cut partly in trap, partly in sediments, and the trap bluffs on either side form as it were a gateway in whose sill the gorge is cut. The lower part of the channel from the gateway to Black Sturgeon lake, except where the river expands to fill Little Sturgeon Lake basin, is a young channel of post-glacial date. It seems very probable that the Spruce river above the gateway is flowing in a direction opposite to that in which the river that once occupied the broad valley above discharged.

In the extreme northwest and northeast corners of the area mapped are small areas of the Laurentian peneplain which drain northward into streams tributary to the Albany river. In the southeast corner of the area, east of the Pijitawabik valley there is a large section of the Archæan areas which drains southward directly

into Lake Superior, through a system of lake basins and swift-flowing streams in which there are many rapids, cascades, and falls.

LAKE BASINS.—Three types of lake basins have been developed in the region. On the granite and gneissoid granite areas, and on the trap sheets in some places, the basins are usually shallow, more or less circular depressions between the adjacent dome-like elevations. The areas of Keewatin rocks are characterized by the presence of numerous lakes, which always occur in the hollows between schist ridges. Owing to the rock structures these depressions almost invariably have a very much greater length than breadth; hence the lake basins are characteristically long and narrow, usually with oval ends. In a few instances old river gorges on the trap-capped plateaus or lowlands, have become blocked with waste, and a longitudinal lake basin with very deep water is found in the upper portion of the blocked channel. In the country west of Black Sturgeon lake several small lakes which appear to belong to this type are found. One of these, Meskwtas lake (the first east of Sucker lake on the map), had a depth of 105 feet, while it is only about a quarter of a mile wide and about 2·5 miles long.

OUTLETS OF THE NIPIGON BASIN.—At the present time there are three depressions leading southward from the Nipigon basin.

The most easterly of these is the Pijitawabik valley or cañon. This depression is a little more than one mile in width, and is bounded by high cliffs of diabase, the edges of the bisected southeastern plateau. Archæan rocks occur on the sides of the valley near water level, and in the lower valley at levels below that of Lake Nipigon; deposits of sediments occur higher up on the sides under the trap sheet. The cañon is about 16 miles in length. It is joined on the east side by a second cañon coming from the northeast. The depression is now blocked with glacial drift and lacustrine deposits. The piles of talus that once must have lain at the bases of the cliffs have largely been removed.

The Nipigon River gorge, the channel by which the whole Nipigon lowland now drains southward to Lake Superior, lies only a few miles west of the Pijitawabik cañon. It is a young gorge, in places not over a quarter of a mile in width. Except in the vicinity of Island portage, both walls of the gorge are formed by the edge of a diabase sheet, the eastern wall rising about 600 feet above the river, the western about 400 feet. In the vicinity of Island portage

the cañon walls are gneiss and granite; both dip slightly towards the north, that on the west having the greater inclination. As already intimated, it is supposed that this cañon has been developed along the locus of a fault zone. This channel is much younger than the channel to the east. In part it may have been developed in pre-glacial times. It probably became an important outlet from the lake basin as the main discharge channel during the interval preceding the last ice advance.

The third depression leading south from the Nipigon lowland is the Black Sturgeon lowland. At the present time the ground morainic material at the head of Black Sturgeon lake forms a low dam, not more than 4 or 5 feet above Lake Nipigon level at high water, which prevents the western part of Lake Nipigon from draining into Black Sturgeon lake. The upper course of the Black Sturgeon river, between the lake and Nonwatin lake, is through a new post-glacial channel, about 20 feet in depth, cut in dolomites. Below Nonwatin lake, to within a few miles of the railway, the river runs along a lowland partly filled with glacial waste, rapids and falls occurring only at a few points. The last section of the river is through a gorge cut in sediments belonging to the Keweenawan. The age of this gorge has not been determined, but it is probably pre-glacial.

ORIGIN OF THE NIPIGON BASIN.—*Earlier Views.*—In 1894 McInnes described the lake as lying in a trough 'excavated in rocks of the Nipigon (Keweenawan) series and in the traps which cut and overflow these sediments, the Nipigon rocks having themselves been laid down in an older basin in the Archæan gneisses and schists.'[1]

In 1898 Dowling, in referring to the deep channel that is known to exist southwest of Livingstone point, suggested that it was 'evidently formed by the denudation of the trap and the underlying sediments down to the original floor, and as the Archæan rocks are found along the eastern margin of the lake overlaid by heavy beds of trap, the slope of the original basin must have been very steep.' He draws attention to the sharp dip in the upper surface of the trap sheet at Livingstone point, nearly 400 feet in a distance of 4 miles, and in discussing the origin of the deeper part of the basin and of the river writes: 'The exposures all along the lake, show the mass to have been much broken by vertical fissures, so that most

[1] McInnes, 15, p. 50.

of the cliffs are subject to frequent falls of rock; but a series of greater fissures would appear to have also been formed upon the cooling of the mass of molten trap. These no doubt surrounded, in an irregular manner, local centres of greater thickness, and were enlarged by the subsequent inking of parts of the basin owing to the displacement of such a large mass of erupted material from below. That these great lines of fissure extended along the eastern side of the basin, is shown by existing traces in the mass of trap confining the southern end of the lake, the outlet by the river being roughly along a great fault or break forming a cañon, the eastern side of which is almost precipitous, and rises to nearly 600 feet, the western side very much lower and decreasing in height northward. Other great faults no doubt run northward between the islands and the ridges on the east shore.'[1]

In 1901 Parks referred to the strong westerly dip of the limestone strata underlying the trap sheets near the foot of Pijitawabik bay. In 1902 he noted a similar strong westerly dip in the sandstones under the diabase sheet at Livingstone point. He summarizes his observations thus:—

'(1) The Laurentian rocks rise rapidly from the shores of the lake.

(2) The sandstone and limestone overlying the gneisses must have been deposited in a horizontal position.

(3) These rocks now dip strongly to the west.

(4) The trappean rock, whatever it may do in *height*, decreases in thickness towards the east.

(5) Gneiss occurs on the lake shore of the south peninsula of Ombabika.

(6) *There is a distinct anticlinal structure* in the trap forming the peninsulas of Ombabika. This is seen at both the north and south extremities of the south peninsula, and at the south end of the north.'

From the above facts may be adduced:—

'(1) A shallow basin in pre-Animikie times, occupied the location of Lake Nipigon; in this were deposited certain limestone and sandstones.

[1] Dowling, 10, p. 97.

(2) Over, or, according to those who attach importance to the undoubted plutonic nature of the trap, between, these beds was forced a mass of diabase.

(3) The weight of this mass caused a sinking in the floor, resulting in the westward dip of the rocks in question.

(4) This sinking was more pronounced at the north end of the lake.

(5) Certain resistant portions of the crust did not yield as readily as others; this is excellently seen on the peninsulas of Ombabika, where the gneiss actually outcrops on the lake side, while it is not to be seen on the bay side of either point.

(6) Faulting probably accompanied the sinking process, and was more pronounced towards the south part of the area.'[1]

By way of comment, the writer wishes to mention that Parks is in error when he states that gneiss occurs only on the west side of the peninsulas at Ombabika. It has been found on both sides of both peninsulas. Nor can he agree with the statement that the sandstones and limestones must have been deposited in a horizontal position. Instances are known where bedded limestones must have been deposited on slopes inclined at angles greater than ten degrees. So far as known to the writer, the general dip of the sedimentary series on the east shore of the lake is less than two degrees; in some few local cases higher dips have been noted, but never at an angle high enough to make it certain that the bed on which the sediments rested had been tilted.

Author's Theory.—The existence of a broad, shallow, basin-like depression on the Archæan rocks, now partly blocked by the central plateau, has already been described. During the period when the sediments were being deposited this Nipigon Archaean basin must have been a broad shallow indentation of the coastline of that time. On subsequent uplift after the sediments became indurated, under normal conditions, belted coastal plain topography would develop. The distribution of the remnants of the sedimentary series over the whole basin, the attitude of the beds, the character of the rocks, and the type of topography now developed, all indicate that such a belted coastal plain actually did develop.

The Black Sturgeon lowland and the western plateau are regarded as possible remnants of this pre-trap belted coastal plain. It is

[1] Parks, 25, pp. 58, 59.

possible that the eastern plateau, beneath which large masses of sediments exist, is also a remnant of a detached portion of the first cuesta. This block of sediments lies in the deeper depression on the Archæan rocks, whose re-excavated portion forms the Lake Helen trough. The writer surmises that the locus of the first consequent drainage must have been southward along the axis of the old depression. The erosion had gone far enough to uncover a very considerable portion of the bottom of this trough before the trap overflow, because in a small side valley close to present water level trap is found resting on the Archæan rocks, while on the main valley side about 400 feet higher up, there are 55 feet of sandstones preserved under a diabase cap.

It is not possible to accurately determine when this coastal plain topography was developed. The portion of the peneplain close to the margin of the sediments, is of pre-Palæozoic age. It is probable that the belted coastal plain features were developed and the ancient peneplain uncovered in post-Cretaceous time, at the same time and in the same manner as the basins of all the great lakes both east and west of this area, along the southern edge of the crystalline highland.

The development of the coastal plain was interrupted by two events, which followed one another some time after the belted character of the plain had been established (block faulting and the diabase invasion). A certain amount of block faulting probably took place prior to the invasion of the district by diabase, because we find at the northwest angle of the central plateau block that the crystalline rocks, which form the core of the block, are sheeted with diabase from the base of the escarpment to its summit; there is no direct evidence of movement along this portion of the block since the diabase was extruded. That any portion of the sedimentary series now remains in the ancient Archæan trough is probably due to the protection offered by the diabase. Following the diabase invasion the region was again subject to processes of erosion and a new drainage system was developed.

During the early stages of this period of erosion a very considerable amount of block faulting also took place, and at the present time some of the blocks are tilted slightly towards the northeast. It is within the limits of possibility that the existence of the depression (over 400 feet in depth, McInnes) southwest of Livingstone point is to be explained by assuming the existence of a down-faulted block beneath this basin. The area of the depression is not known;

its bottom is lower than that of the known outlets of Lake Nipigon, and lies about 150 feet below the level of Lake Superior. The depth of the Pijitawabik depression, and the depth of the lowest part of the Lake Helen trough are not known. The slopes of the sides of this trough are similar to the slope of the known portion of the eastern side of the Livingstone Point depression. The two depressions do not appear to be aligned, however, though both are developed in a direction transverse to the rock structures, and may be two disconnected portions of a deep valley, first buried beneath sediments and diabase, re-excavated, and now partly filled with glacial waste and submerged. The writer would hesitate to ascribe the Lake Helen trough to block faulting, because the features of the trough sides are such that there is no reason to believe that it was formed by any other process than normal valley erosion. In the absence of conclusive evidence to the contrary this method of formation would also seem to account for the major depression of the bed of Lake Nipigon.

Much of the faulting and tilting of the fault blocks took place in this district long after the trap had solidified, because many of the trap sheets are now disconnected; some of the faulting antedates the diabase invasion. For this reason the writer suggests that most of the trap overflow should be attributed to those disturbances which took place in the basin of Lake Superior during post-Keweenawan time, when the lake basin was in process of formation.

Nothing definite is known about the extent of the trap sheets southward over the Lake Superior basin. They all now end abruptly at a high elevation along the north shore of the lake. It is possible that the elevation of the northern rim of Lake Superior was coincident with the depression of the lake basin. During the elevation of this rim the various fault blocks of which it is now composed were both developed and tilted. It is a rather remarkable fact that a plane passing from the summit of Thunder cape, the highest sheet of trap along the Lake Superior rim, to the summit of the highest trap remnant northeast of Lake Nipigon, would pass less than one hundred feet above the eastern plateau, the central plateau, and the summits of several of the highest ridges on islands in the lake. Because of this the writer tentatively infers that while the whole area has been tilted northward sometime since the diabase invasion, there was a certain amount of differential movement along the edges of the fault blocks whereby the northeast edges of portions of

hese blocks were not elevated so much as the adjacent edges of the neighbouring block, just as if the blocks had jostled each other and become tilted during the process of general elevation of the rim.

There does not appear to be any means of gauging how much of the erosion of the trap sheets took place prior to the elevation of the region, how much while this movement was in progress, and how great it has been since the movement practically ceased. The total amount of erosion on the trap sheets has been enormous. It has already been stated that the portion which now remains is only about 10 per cent of the whole. Until some means are obtained of differentiating the several fault blocks, and determining the amount of their relative movements, and thus reconstructing the old pre-trappean topography, it will be impossible to make accurate estimates of the total amount of erosion.

The history of Lake Nipigon basin is thus very complicated, and the evidence now available is very incomplete. As a tentative theory, based on such evidence as has already been discussed in the preceding paragraphs, the writer regards the development of the basin as having been consequent on the operation of the following causes:—

(1) Primarily, the existence of a trough on the Archæan surface, which formed the basin in which the sedimentary series were deposited.

(2) Development of belted coastal plain topography and the uncovering of portions of this trough.

(3) Blocking of early drainage lines by diabase flows and intrusions.

(4) Re-development in a greatly modified form of the principal pre-diabase features.

(5) Block faulting and differential uplift, associated with those major crustal movements which resulted in the development of the Lake Superior basin and the elevation of the northern rim of that basin.

SUMMARY STATEMENT OF THE GEOLOGIC HISTORY.

The sequence of events which have taken place in this district since the period when the Keewatin volcanic series were deposited, may be summarized as follows:—

(1) Folding and plication of the Keewatin series, accompanied by metamorphism during a batholithic invasion of these sediments, and by mountain building.

(2) Period of degradation during which the Keewatin rocks were greatly eroded and the debris which forms the rocks of the lower Huronian was deposited.

(3) Further folding, accompanied by batholithic invasions and metamorphism.

(4) Extremely long period of erosion during which extensive peneplanation took place.

(5) Period during which large portions of the soil cover of the peneplain surface were removed and a hummocky or mammillated topography of the crystalline areas was developed.

(6) Period of submergence during which immense deposits of sediments were formed.

(7) Elevation above sea-level, followed by extensive erosion, culminating in the uncovering of large portions of the buried floor which had been covered by the sediments, and the development of a belted coastal plain topography. Movement on the fault planes probably also took place during this interval.

(8) Period of diabase invasion.

(9) Period of further extensive erosion, during which the greater portion of the diabase was also removed. With the diabase large masses of the sediments, which had remained after the former period of erosion, were also removed.

(10) Period of further disturbance, during which the northern rim of the Lake Superior basin was elevated. Extensive block faulting also took place. Some of these movements were probably contemporaneous with the period of erosion following the diabase invasion, some may have been in operation during that invasion.

(11) Period of further erosion, during which the two principal pre-glacial drainage systems were developed, and the plateau blocks were greatly dissected on their margins. During this interval the peneplanation which produced the surfaces of the two large lowlands probably took place. Near its close, for a short interval, there was a local change in the baselevel, and certain cañons were cut. (This may have been interglacial cañon cutting, in which event the incident should be referred to the next period.)

(12) Period of ice invasion, during which all the earlier outlets were blocked, and much loose waste was transported shorter or longer distances. (The number of interglacial intervals is unknown.)

(13) Period of ice retreat, during which the region was more or less covered by a series of glacial lakes, which later became confluent. During this interval extensive stratified deposits of loose waste were formed.

(14) Period following the ice retreat, when the present lake basin with its drainage system was established.

ECONOMIC GEOLOGY.

The only metallic ores of which indications have been found within the Nipigon basin are the ores of gold and iron; no workable deposits of the ores of either metal have yet been discovered. Some small areas are probably of value for their agricultural possibilities. The most important economic asset of the district is probably to be found in its water-powers.

Auriferous Quartz Veins.

Small quartz veins and stringers are frequently found in some of the Keewatin schists. Parks reports an assay value of $1 per ton in gold from a sample secured at Cross lake.[1] Robinson obtained an assay return of 80 cents per ton from a sample brought from near Summit lake; another sample from the Lily river gave $2.80 per ton.[2] A number of assays of other samples from different localities yielded no values.

Numerous small quartz veins and stringers, similar to those described by Parks and Robinson, from the vicinity of Cross and Summit lakes, also occur in the green schists between Round and Caribou lakes. It is quite possible that prospecting might disclose larger and richer veins. As a rule veins of this type have not proved to be of value. Locally very rich pockets of ore have been found, but the occurrences have been too scattered and irregular to be operated at a profit.

Some attempts at gold mining were made on some similar quartz veins in the Poplar Lodge area in 1884, by C. S. Morris, but they appear to have been unsuccessful.

Iron Ores.

Ores of iron have been reported from three different localities within the boundaries of the area mapped; these are, north of Round lake, east of Black Sturgeon lake, and from the Poplar Lodge

[1] Parks, 25, p. 60.
[2] Robinson, 28, p. 165.

regic , this latter including a large area east of Poplar Lodge and south of the Sturgeon river. A fourth district lies just east of the mapped area at the headwaters of the Onaman river.[1]

Round Lake Region.

This region was examined in detail by E. S. Moore in 1908.[2] Moore found the known exposures of the iron range rocks to be very small, and no ore bodies of importance have been found.

Black Sturgeon Lake.

Discoveries of hematite in the district east of Black Sturgeon lake and north of Nonwatin lake led to the location of a number of claims in this region in the seasons of 1901 and 1902. Hematite in small quantities was found in a number of localities along the base of an escarpment close to the contact between Archæan rocks and the Keweenawan series of sediments, and it was supposed that an iron range existed in this locality, extending in an east and west direction for about seven miles. No iron range rocks similar to those found elsewhere in the district have been reported in this locality.

The hematite occurs as small stringers and veins in the Archæan rocks (Keewatin schists, Laurentian gneisses and granites), and also as a cementing material occupying the interstices between fragments of these crystalline rocks. These bodies of breccia, cemented with hematite, are large, more or less lenticular masses, and are found along the base of a prominent escarpment which is made by the southwest edge of the central plateau. In all probability this escarpment is the edge of an old fault block, and the breccias are fault breccias. Coleman has suggested that they may be talus blocks at the foot of a cliff. A small amount of exploration has been carried out by sinking test pits and by diamond drilling. The logs of the drill-holes are not available, but on the ground it appeared to the writer that the holes had all been placed in the Keewatin schists. which are destitute of hematite except in the vicinity of the breccias. No holes appear to have been located with a view to exploring the breccias in which the hematite occurs.

So far as seen the hematite makes up only a small proportion of

[1] Moore, 19.
[2] Moore, 20.

the whole mass of the breccia, the rock fragments themselves being destitute of ore. No large masses of ore have been discovered, and the geological conditions are such that it is extremely improbable that any bodies of ore of commercial importance occur in this locality.

Some of the gneiss from this vicinity carries a large amount of hematite in small plates, scattered through the mass of the rock. In addition, veins of the nearly pure mineral occur in both the granite and gneiss. In places the hematite is present in an amount large enough to make it an important constituent of the rock. The hematite in the veins, and that forming the cement of the breccia are undoubtedly secondary, and must have reached their present situation by infiltration. It appears probable that the original source, so far as these veins and the breccia are concerned, may have been the gneiss adjacent. Whether the hematite in the gneiss is a primary constituent or is a residual decomposition product of some of the original constituents has not been determined. The hematite gneisses occur at many points between Black Sturgeon bay on Lake Nipigon and Frazer lake, and not always associated with Keewatin schists.[1]

Iron Ranges East of Lake Nipigon.

These ranges have been studied in great detail by Coleman and Moore during the seasons of 1906 and 1907, and the results of this examination have been published in the reports of the Ontario Bureau of Mines for 1907 and 1908. The following statements are abstracted from these reports:—

POPLAR LODGE AND STURGEON RIVER REGION.—The Iron formation is the highest, or almost the highest, part of the Keewatin, and extends in long bands, with many gaps, from Lake Nipigon to beyond the eastern boundary of the map sheet. It provides almost as definite a horizon as the lower Huronian conglomerate, but the bands are in general found to be narrower. In some places three parallel bands a mile or two apart may be distinguished, but this is by no means the case everywhere.

The materials of the Iron formation in the Nipigon region are always silica in some form and an oxide of iron, magnetite or hematite; never siderite nor sulphides, as in the Michipicoten region.

[1] See also Coleman, 7.
[2] Coleman, 5 and 6. Moore, 18, 19 and 21.

There are two types of formation, one consisting of interbanded quartzite or cherty silica with magnetite, the other of jasper with hematite, but there are mixtures of the two varieties in many places. The dark variety of the iron range is often intermixed with a grey slate, and the leaner parts seem to grade into the latter rock, containing less and less magnetite until the compass is no longer affected. The jaspery variety is a very showy rock, with bands of bright red and glistening black hematite, intricately folded and crumpled, and cut by narrow veins of white quartz which have also been crumpled. The actual jasper and hematite may be in rather long, narrow elongated strips with grey schist between, so that a cross-section may show many alterations of banded jasper and schist instead of continuous jaspery material. Intermediate varieties between the extremes described may contain magnetite enough to make the compass useless, along with some strips of dull jasper and so much hematite that the powder of the ore is red.

Three distinct bands of Iron range rocks have been located in the Poplar Lodge area and north of the Sturgeon River valley. These are usually referred to as the Northern, Central, and Southern ranges. Farther east, in the vicinity of Lake Windigokan and some other small lakes, several bands of Iron range rocks have been located; these latter may be collectively referred to as the Windigokan ranges.

The Northern iron range has been traced for about one mile. The iron formation is silica in the form of jasper, and it is a finely-banded rock with red, grey, green, and white layers replacing the usual white or grey and black. Most of the ore appears to be black magnetite; in places it is present in the banded silica in an amount large enough to seriously disturb the compass. No ore bodies of value have been located.

The Central iron range lies about 3 miles south of the Northern range, and has been traced for about 3 miles in an east and west direction. 'Summing up matters for the Central range, outcrops of jasper and rich or lean hematite have been found in 6 areas of considerable magnitude, scattered through a plain largely covered by sand and peat bog. From east to west they extend three miles, with an average strike of 70° or 80°, while from north to south . . . . there is a greatest width of five-eighths of a mile-- over 3,000 feet. Whether some of these different areas are really connected beneath the swamp and sandplains is uncertain, but fairly probable. While the width of the formation is usually great, the

PLATE XIII.

Photo by R. Harvey, jr.

Falls below the head of the portage at Camp Alexander

PLATE XIV.

6618-p. 140

Falls above Cameron pool.

Photo by R. Harvey, jr.

banded ore and jasper is generally much interrupted by interbedded grey schist, which often contains a good deal of siderite, but must be looked on as greatly diminishing the total amount of iron in the formation available for concentration in secondary ore bodies. In the close interbedding of schist with the banded silica and iron ore, this iron range presents a feature seldom found in other iron ranges of the Lake Superior region, a feature which cannot be considered promising; but taking into account the great width of the range, three times the width of the Helen Iron formation, for example, there still should be abundance of iron available for the production of secondary ore bodies. Up to the present, however, no large bodies of such ores have been found.'[1]

The Southern range lies about two-thirds of a mile south of the Central range, and has been traced for about seven and a quarter miles, with very few interruptions. It is not so wide as the Central range. Like the smaller Northern range, it contains a good deal of magnetite as well as hematite, and some jasper; while the Central range is entirely free from magnetite.

The total area of Iron formation in the three ranges is large, but the interbanding of green slate and grey and green schist greatly cuts down the amount of iron contained by them. Nevertheless there has been plenty of the metal to form ore bodies by downward concentration in several parts of the field, the most promising localities being those near the camp in the Central range, and the west and east ends of the Southern range.

It is probable that the Northern and Southern ranges are each a narrow syncline enclosed in the grey and green schists of the Keewatin; while the Central range may represent a number of parallel close folds less vigorously compressed in the mountain building process. If this assumption is correct, the ranges consist of the lower part of greatly denuded canoe-shaped synclines, and the green schists enclosing them should afford fairly impervious basins. In only one case (Claim H.L. 414) was the Iron formation discovered to be interrupted by a dike giving a possibility of a basin cut off from some pitching syncline; and here there is a small amount of good ore.

Character and Relationship of the Ore.[2]—'While the Iron formation is widely and thinly diffused in many cases, and inter-

[1]Coleman, 5, p. 123.
[2]Coleman, 5, pp. 126-129.

mixed with much slate and schist, there are a few places where seams of a few inches or a foot or two of ore occur, suggesting secondary concentration on a small scale. Generally, even these richer parts show a small amount of interbanded silica, often in the shape of jasper; but when broken so as to expose the shiny surfaces of blue hematite, the ore looks very attractive. Assays show, however, that even at these points the percentage of iron is low, though there is very little in the way of injurious impurities, minerals suggesting sulphur and phosphorus being largely absent, and titanic mineral entirely so.'

'The region was visited in 1900 by Mr. J. Watson Bain, who collected a number of samples from the Southern range, afterwards assayed with the following results:—

	1.	2.	3.	4.	5.
Metallic iron..	38·06	30·06	37·19	37·79	34·02
Silica..	40·60				
Sulphur..	traces.				
Phosphorus..	traces				
Titanium..	none.				

No. 1 was the best sample; No. 2 represents an average sample of the formation for a width of 82 feet; and No. 3 an average of 54 feet, excluding the leaner part of the outcrop. No. 4 was taken in the same way, but 100 feet west, and No. 5 from 300 feet east, all apparently being from location 826 X.[1]

A specimen of magnetite and hematite mixed, the richest looking ore obtained by myself from the Southern range, on location 826 X, yielded 45·27 per cent of iron (soluble) and 0·52 per cent of iron in the residue, when assayed at the Provincial Assay office in Belleville; and the best specimen from 827 X gave 34·20 per cent of iron.

Three samples of ore taken by myself from the Central range gave similar results when assayed at Belleville:—

	1	2	3
Hematite (iron soluble)..	43·74	36·86	39·66
" (iron in residue).. ..	0·45	0·60	0·35

Nos. 1 and 2 are from H.F. 5, and No. 3 from A.L. 414.

In a report on the region from Prof. Willmott, communicated by the kindness of Mr. Henry Weill, of Buffalo, hard blue hematite

[1] Bain, 1, p. 213.

from a lens on the surface is stated to have the following composition:—

Iron	
Silica	64·420
Phosphorus	3·800
Manganese	0·071
	0·100

This was probably a carefully selected sample, since the average of the ore penetrated by drill-holes is stated to be only 40 to 50 per cent.

Three drill-holes were put down on the iron range, on locations A.L. 413 and A.L. 416, the latter being south of the former, one by Mr. Flaherty, and two by the Algoma Commercial Company, one of them under the direction of Prof. Willmott.

The first hole, on the north side of the formation, was sunk 628 feet at an angle of 45°, equivalent to 440 feet across the formation. 'It passed through a number of bands of lean ore varying from 2 to 16 feet in thickness and from 40 to 50 per cent in iron. A second hole, which was really put down first, started directly over the bottom of the first and was bored for 512 feet at an angle of 60°. This crossed 271 feet more of the formation. "The core revealed continuous jasper with narrow bands of hematite, and at the bottom a passage into quartzite." The portion reported as jasper contained a large amount of iron, and the "narrow bands of hematite" were nearly pure ore. A third hole crossed the balance of the formation with similar results.'

The above quotation from Prof. Willmott's report, kindly placed at my disposal by Mr. Leitch, gives a good general idea of the relations of ore and country rock on the two locations.

Adding up the amounts of ore recorded in the bore-hole of 628 feet, there are in all about 36 feet on the dip of 45°, or about 25 feet measured horizontally. The other two records show about 7 feet of ore each, which amount to 3½ and 5 feet respectively; so that the total width of ore shown in the section cut by the drill-holes is about 33½ feet, the rest being mainly jasper and grey schist.

In general, it may be said that in the aggregate there is a considerable amount of lean ore with comparatively small amounts of injurious impurities, but generally in narrow lenses separated by several feet of jasper and schist. It is of interest to note that ore was struck at a depth of 414 feet, showing that the formation is not shallow. Very little pyrite occurs in the banded silica or ore, but the intervening grey schist generally contains small crystals.

This section of the ore shows minutely crystalline silica through the magnetite of the Northern and Southern ranges and the hematite of the Central range. Where magnetite is the ore there is a possibility of magnetic concentration; but the feebler magnetism of the hematite would probably render it incapable of concentration by this method. In any case the particles of ore are small and would require fine pulverization and subsequent briquetting or agglutination to make it available for the blast furnace.

In some of the 'blue' hematite ore there is a considerable amount of chlorite instead of finely granular silica mixed with the oxide of iron. This accounts for the iron in the insoluble residue reported in the assays given above.

As the Northern range seemed on the whole lower in grade than the others, no samples from it were sent for assay.'

WINDIGOKAN IRON RANGES.—Iron formation occurs at three localities in the Windigokan region: these are west of Windigokan lake, at Still lake, and northeast of Watson lake. There are also a number of small unimportant outcrops occurring at other points in the region.

The Iron formation is banded jasper, associated with grey slate and schists. The outcrops near Watson lake show some magnetite associated with the jasper.

No ore bodies of importance have been found.

Marl and Peat.

Reference has already been made to the occurrence of deposits of marl and peat in some of the small lakes and swamps in various parts of the district around Lake Nipigon. They are all too inaccessible to be of immediate economic importance.

Agriculture.

The numerous large sandplains of lacustrine and alluvial origin, which occur in the lower parts of the valleys of the principal streams tributary to Lake Nipigon, are covered with a light sandy soil, in places somewhat argillaceous. Portions of these plains are probably suitable for cultivation. Their area is limited, and the district will probably never become more than locally important for its farm produce.

PLATE XV

Split Rock rapid, below the portage.

PLATE XVI

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Virgin falls.

Water-powers.

Apart from the natural products of the district, probably the most important commercial asset of permanent value is its water-power. On all of the streams tributary to Lake Nipigon there are falls and rapids, several of which could be utilized locally for the manufacture of wood pulp and its products, it being assumed that the fishery regulations which now prevent timber being floated down the Nipigon river are maintained. The flow of these streams is small, and the total amount of power that could be developed at any one point would not be large.

The Nipigon river, however, in its descent to Lake Superior, about 250 feet, affords one of the most magnificent water-powers in central Canada. It is probable that, should circumstances warrant it, nearly 175 feet of this fall could be utilized for practical purposes. The various power sites along this river were investigated by the Hydro-Electric Power Commission of the Province of Ontario in 1906.[1] The following table, showing the head and power available at certain localities along the river, is taken from their report:

Water power.	Head.	Estimated Low Water Flow. F.S.	Minimum 24 hr. Power. H.P.	Remarks.
Cameron rapids	[illegible]	[illegible]	19,500	14 miles from Nipigon station.
Splitrock	[illegible]	[illegible]	7,500	
Island portage	[illegible]	[illegible]	4,750	
Pine Portage rapids				
White chute	[illegible]	[illegible]	6,000	
Victoria rapids	[illegible]	[illegible]	5,000	
Camp Miner rapids	[illegible]	[illegible]	3,500	
Virgin falls	[illegible]	[illegible]	12,500	30 miles from Nipigon station.
Flatrock	[illegible]	[illegible]	19,000	

The Nipigon river is the largest stream entering Lake Superior, and its drainage basin covers an area of over 6,000 square miles, in a rocky district where the average annual rainfall is probably over 20 inches. Lake Nipigon could also be converted into an excellent storage basin at a relatively very small expenditure, permitting

[1] Fifth Report, page 14, *et seq.*

the regulation of the flow, and rendering it possible to largely increase the rate of flow above the minimum figures given in the report of the Commission. At the present time the nearest large centres of population are at Port Arthur and Fort William. The distance from Port Arthur to the Canadian Pacific Railway bridge over the river is a little under 66 miles. A power plant at Cameron pool would be 11 miles, and one at Virgin falls would be about 30 miles north of the railway, and each would be about 85 miles from Port Arthur.

The Nipigon River powers will probably best serve pulp and paper mills, or electric smelting plants situated somewhere on Nipigon bay, where the shores give excellent opportunity to establish good harbour facilities.

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CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH.

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
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(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

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* Publications marked thus are out of print.

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715. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.

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*260. Yukon district, by G. M. Dawson. 1887. Maps Nos. 274, scale 60 m. = 1 in.; 275-277, scale 8 m. = 1 in.
295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. = 1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. [illegible], scale 2 m. = 1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. [illegible], scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. = 1 in.
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982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. = 1 in.
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212. The Rocky mountains (between latitudes 49° and 51° 30°), by G. M. Dawson. 1885. Map No. 223, scale 6 m. = 1 in. Map No. 224, scale 1½ m. = 1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
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*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556-7, scale 4 m. = 1 in.
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266. Lake Superior, mines and mining, by E. D. Ingall. 1888. Maps Nos. 285, scale 4 m. =1 in.; No. 286, scale 20 ch. =1

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[illegible]. Megantic, Beauce, Dorchester, Levis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
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975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
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1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m. = 1 in.

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290 Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-88. Map No. 290, scale 4 m. = 1 in.
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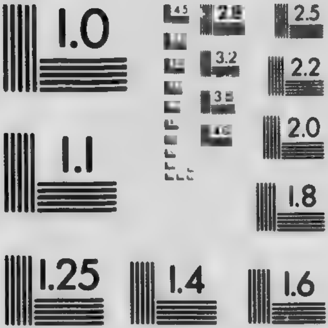

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Applications should be addressed to The Director, Geological Survey, Department of Mines, Ottawa.

Depa
GE

HON W TEMPLEMAN

EXPLORATORY

LEGEND

PRE-CAMBRIAN?

KEWEENAWAN

POST-NIPIGON

Diabase
diabase sheets and dikes later acid dikes

A3

Nipigon formation
conglomerates sandstones shales and dolomites

PRE-CAMBRIAN

Huronian
conglomerate and probably arkose and slate

2

Laurentian
granite gneiss grey schists

Granite porphyry

A1

Keewatin
greenstones mica schists amphibolites iron formation with some slaty schists

Symbols

Geologic[illegible]undary

Canada
Department of Mines
GEOLOGICAL SURVEY

Templeman Minister, A. P. Low, Deputy Minister
R. W. Brock, Director

1910

NORTHWESTERN ONTARIO

LEGEND

Railways

Projected railways

Trails and Portages
distances given in chains

Rapids and Falls

Marshes

Hill sketching

Mining claims

Geological boundary

Strike

Strike and dip

Glacial striae

Iron

C.C. Senécal Geographer and Chief Draughtsman
A. Dickison, G.G. Aitken and B. Lefebvre Draughtsmen

LAKE

THUNDER

(Northwestern On

Sca

4 MIL

Sources of Information

Exploration ... al and other surveys by Mess^rs R. Bell W^m M^c Innes D. B. Dowling W. ... Parks A. W. G. Wilson W. H. Collins *of the* Geological Survey *and* ... *of the* Bureau of Mines of Ontario.
Official plans of the Ontario Crown Lands Department *and of the* Department of Indian Affairs.
Exploratory and location surveys of the Canadian Pacific, *the* Canadian Northern, *the* Grand Trunk Pacific *and the* National Transcontinental *railways.*
Compilation ... Johnson.

MAP 8A

LAKE NIPIGON
THUNDER BAY DISTRICT
ONTARIO
(Western Ontario series, N^os 11 and 17)

Scale: $\frac{1}{253,440}$

Miles: 0 — 10 — 15
Kilometres: 10 — 15 — 20 — 25

4 MILES TO 1 INCH

To accompany Memoir N^o 1